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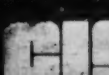

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NOAA ENVIRONMENTAL SATELLITE PROGRAMS

HEARING

BEFORE THE

NATIONAL OCEAN POLICY STUDY

OF THE

COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION UNITED STATES SENATE

ONE HUNDRED FIRST CONGRESS

SECOND SESSION

ON

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION ENVIRONMENTAL SATELLITE PROGRAMS

JUNE 12, 1990

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NOAA ENVIRONMENTAL SATELLITE PROGRAMS

TUESDAY, JUNE 12, 1990

U.S. SENATE,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
NATIONAL OCEAN POLICY STUDY,
Washington, DC.

The Study met at 9:43 a.m. in room SR-253, Russell Senate Office Building, Hon. John F. Kerry [Vice Chairman of the study] presiding.

Staff members assigned to this hearing: Penny Dalton and Grant Cunningham, professional staff members and Louis Whitsett, minority staff counsel.

OPENING STATEMENT BY SENATOR KERRY

Senator KERRY. This hearing will come to order. I apologize to everybody for the delay in starting, but we had a vote that started about 15 minutes earlier than anticipated which threw my schedule off, and I apologize.

I would like to welcome everybody here to this hearing to discuss the future of satellite programs at NOAA. NOAA is obviously going to continue to play an increasingly important role in advancing the use of satellites to meet the ever-increasing demand for information on a number of critical issues, ranging from environmental research and countless numbers of other scientific needs for further knowledge, to national security and other issues that we face.

Clearly, satellite information has taken on an increasingly important role in our society, as we will hear from some of those who use it on a daily basis. A simple indication of this importance is demonstrated by our reliance on television and the images that we get for daily weather forecasts, and the way in which that reliance has affected our lives.

We are going to discuss a number of important budget and policy issues today relating to NOAA's satellite programs. These are principally focused on the following: launch delays and cost overruns in the geostationary weather satellite program; the land remote sensing requirements to meet the nation's needs in defense, agriculture, environmental protection, and drug interdiction; the use of satellites to assess global environmental threats, such as acid rain, climate change, deforestation, and desertification; and finally, the application of satellites for search and rescue operations and tracking fishing vessels.

NOAA's geostationary satellites now provide complete continuous observations of the western hemisphere, and they are particularly valuable in predicting and tracking hurricanes. Timely

launches are needed to ensure the continuity of the GOES information.

Unfortunately, there are some problems that we have become aware of, and which have been acknowledged, regarding the instrumentation and spacecraft development for the next series of GOES satellites. These problems have caused launch delays and have helped drive costs up from an original estimate of some $550 million to about $750 million. Even at these higher costs, there are questions about the ability of the contractor to meet the current launch schedule.

Remote sensing data from NOAA's Landsat program provides global information on physical characteristics and land use activities of the Earth's surface. Those data are used to assess agricultural crops, pollution sources and transport, population growth, development trends, and geological characteristics for petroleum and mineral extraction.

These data are invaluable for assessing the global environmental problems that I referred to. Yet, the future of Landsat is in question. The Administration is supporting the development and launching of Landsat 6, but for the moment both Landsats 4 and 5 remain unfunded, even though their life cycle is expected to continue at least, I understand, through Fiscal Year 1991.

So these are some issues that clearly we want to discuss at this hearing. We also want to examine in larger terms the importance of the satellite programs to all of us and what we might be doing in order to guarantee that their information is being appropriately gathered and disseminated among the scientific community. These activities are critical to our ability to make the best use of these data.

So I look forward to this hearing as a means of exploring some of those policy issues and some of our options. Let me turn to Senator Pressler and ask if he has an opening statement.

OPENING STATEMENT BY SENATOR PRESSLER

Senator PRESSLER. Thank you, Mr. Chairman.

I'd like to make several points here, and I look forward to listening to as much as I can this morning, keeping in mind the variety of hearings going on and other activities that we are called on to perform.

Mr. Chairman, first of all, I want to thank you for calling this important hearing on the National Oceanic and Atmospheric Administration's satellite programs. It is a timely issue for our nation and the world.

Our geostationary weather satellite program is at a critical juncture in its mission. I am anxious to hear the Administrator's status report on that.

I am also quite concerned about a related National Weather Service program involving the controversial NEXRAD program. I met with Dr. Friday on this subject. Our entire Congressional delegation, Senator Daschle, Congressman Johnson and I, met with Weather Service officials in Huron, South Dakota, to discuss the future of that office.

The current proposal would leave a substantial part of South Dakota without adequate weather coverage in my opinion. No satellite program can make up for that. The original legislation for the NEXRAD program theoretically guarantees that there will be no deterioration in service. But as my conversations with the Weather Service have proved, there seems to be little or no teeth in those words.

I plan to have an amendment later on that, Mr. Chairman, to put some teeth into that language. I am working with a number of colleagues who have been faced with similar frustrations in their states. I have a few questions in that area.

I realize I am straying a bit from the satellite program at issue today, but I wanted to express for the record my displeasure with the current situation.

Another NOAA satellite program of importance and particular interest to me is the Landsat program. I have a long history of involvement in this issue and it is no surprise to members of this committee that I have a parochial interest as well.

The EROS Data Center in my home State of South Dakota receives, processes, and archives Landsat data. It has for two decades done a superb job in that area. Mr. Chairman, I was one of those in the minority when the Landsat commercialization was first proposed over a decade ago. I said then that I did not believe it would work, but I reluctantly worked with the system to make it the best that we could.

It is without any glee that I state today that I believe that my original assessment was correct. Landsat commercialization has not and will not work in today's environment.

Since the 1984 Commercialization Act went into effect, the privatized Landsat system has not even come close to reaching the optimistic expectations of its boosters. We saved no money. Indeed, it has probably been more expensive.

I have heard from many users within the Landsat community—private, academic, and government agencies—that Landsat commercialization has not been successful. The United States is falling behind other countries in this technology, surrendering our historic competitive advantages. We have gone from relatively wide utilizations of the data on the part of the universities and nonprofit groups to a very limited market out there.

This is not just a question of sales or utilization. It is a matter of deteriorating applications research, university participation, and decreased data utilization all around. High prices and copyright restrictions brought about by commercialization have not only increased the cost of the data, but also made it virtually unavailable to the broader scientific and academic communities for such important study as long-term global change.

In short, the great development by the private sector envisaged in the 1984 Commercialization Act has not happened. I doubt that it will happen.

On a brighter note, Vice President Quayle's National Space Council has recognized the fundamental importance of the Landsat technology and has committed in theory to its continuation after Landsat 6. But I have seen no proposals to date on exactly how we

are going to accomplish that goal. We need to get going. We need a budget; we need a plan.

We need to develop a budget and a blueprint for post-Landsat 6 operations. So far we have a commitment, but we need start-up funding within the next year or two to begin planning and designing the follow-on satellite for Landsat 6. So I am not raising a futuristic problem; I am raising an issue with which we must grapple today.

In my view, recent history has made it painfully clear that we cannot turn to the private sector for the answers in this particular area. In my view, Landsat, like the weather satellite program, is fundamentally a public sector program. We saved neither time nor money with this attempt to commercialize. We gave it our best shot. We failed. Let's move on to save the program.

Particularly in light of the environmental concerns, Landsat has a compelling role to play in the area of global change. It has been used effectively in policing and drug detection programs and is vitally important to our national security and our natural resource management program, among other things.

If we are going to move out of the commercialization mode, which I propose, perhaps the Department of Commerce should no longer be required to manage the Landsat program. We ought to move it to a user agency which has a more direct and compelling interest in the program's future. The Department of Defense has been extraordinarily supportive of the program over the years.

But some in the academic community have expressed concern that under defense or intelligence community management, access to data might become a problem. The Department of Interior, another key agency involved in the program for many years, is a data user and might be a more realistic manager of the program. The Department of Interior seems like a logical choice to manage the program in conjunction with other key agencies, such as NASA, the Department of Defense, the Department of Agriculture, Commerce, and others.

The purpose would be to make these data available on a wider basis, stimulate academic involvement, and further scientific research.

Whatever the procedure, we need to get going on a plan. It would be a mistake to delay a decision. As we have learned in the Savings and Loan fiasco, delaying the tough decisions is not going to save us any money!

I look forward to discussing this with the Administrator and others today, and to moving the debate on this subject forward. In short, I would propose that we: first, scrap the commercialization plan; second, shift management of Landsat from the Department of Commerce to the Department of Interior; three, make the funding decisions now and include them in agencies' budgets in the next year or two; and four, reach out to the scientific and user community to find exactly what type of satellite follow-on we need after Landsat 6.

We also need to assure operations funding for Landsats 4 and 5 which are still operating. Whatever we do, it will require modifying the 1984 Commercialization Act. I plan to propose such legislation. We do need to get going, to make some tough decisions early, so we

can not only save money, but also protect the overwhelming scientific investment we have already made in this tremendous program.

Let me say that this morning I hope we cover in some of the statements of the witnesses your opinions of whether commercialization has worked well. We also should discuss Landsat 4 and 5 operations funding. There is no outward sign that they are going to stop in the next year. Landsat 6 probably will not be operational until 1992. Are we going to have funds to operate 4 & 5 and where will the money come from? Everybody seems to be talking without a specific plan or any funds.

And assuming there is going to be a Landsat 7, when should we start budgeting design and startup money to get the process going? How widely is the data being used currently? It has been my understanding that the actual number of products being used by universities, scientists, and other users has dramatically declined. Do you keep numbers on that? If you do, I hope you will emphasize them in your testimony.

If we do away with the commercialization business and decide to fund Landsat as a public sector program, would you be opposed to transferring operation and management of that program to a user agency, such as the Department of Interior?

And finally, how much have we spent on the commercialization of the Landsat program? These are questions I want addressed. If I have to leave for another hearing, I will submit them for the record. But we need answers.

I think we are at a crossroads. I think the time has come for us to really decide where we, as a nation, are going with this program. We must stop drifting. That is my view.

Thank you, Mr. Chairman.

Senator KERRY. Thank you very much, Senator Pressler.

I have an opening statement that Senator Hollings would like to have included in the record.

[The statement follows:]

OPENING STATEMENT BY THE CHAIRMAN

The purpose of our hearing today is to review the environmental satellite and data management programs of the National Oceanic and Atmospheric Administration (NOAA). I look forward to continuing today the Committee's close examination of the operation of, and funding for, these important programs.

NOAA's satellite systems once were considered the frontier of space technology, but now they are part of our everyday lives. We see their images from space on our local television newscasts, and rely on them for routine decisions about what to wear the next day, and even more importantly for extraordinary decisions such as whether the threat of a hurricane warrants evacuation to safer ground. Although they are expensive, the unique view of the Earth from these satellites in space offers benefits unmatched by any other type of observation system. Consequently, one of my highest priorities is to ensure that necessary, and cost-effective, actions are undertaken to prevent gaps in satellite service which may threaten public safety.

Such a gap in service now appears increasing likely for NOAA's geostationary weather satellite (GOES) program. The United States currently has only one GOES satellite in service, rather than the two required to provide complete coverage. Furthermore, the contract to procure additional satellites has experienced considerable problems. We have seen huge cost increases and delays in the launch schedule for the first replacement satellite, GOES-I. If further contract and delivery problems occur, we run a serious risk of satellite failure that could impair the issuance of timely advisories and warnings by NOAA's National Weather Service. I do not know which problem to worry about the most, the cost overruns or the launch delay, but we must monitor NOAA's procurement of these new GOES spacecraft closely and see that adequate contingency plans are in place to ensure public safety in a no-GOES situation.

The GOES problem is particularly troubling given the importance of GOES information for identifying and tracking severe storms on both coasts of our Nation. Last September, we all watched anxiously as Hurricane Hugo roared through the Virgin Islands and Puerto Rico and towards the U.S. mainland. For that week, GOES images dominated our televisions around the clock as the National Weather Service worked to track and forecast the storm's murderous path. One of our witnesses today credits those images with ensuring the safe evacuation of 350,000 people from Charleston, South Carolina. Securing funding for NOAA's satellite programs may be one of the most important services I, and my fellow Members, can help provide, not only to the citizens of South Carolina, but also to the entire nation.

Turning to data management, as we enter an era of increased attention to the global environment, we begin to appreciate the past investments we have made in long-term monitoring programs such as NOAA's satellite programs. When these satellite systems began operations to support weather forecasting over 25 years ago, few would have guessed the immense value of their observations to future scientists focusing on global environmental research. After those many years of continuous service, one of today's greatest challenges is to organize the vast data sets collected and turn them into information that can be shared in worldwide efforts to understand and predict changes in our planet's environment.

With its mission of observing, monitoring, and predicting the Earth's environment, NOAA makes a lie of the old adage that "everybody talks about the weather, but nobody does anything about it". Indeed, NOAA does do something about improving our understanding of the weather, and its satellite systems and services are critical to development of that understanding. For my part, I intend to work to secure the continued presence of such important systems and services.

Senator KERRY. Dr. Knauss, thank you very much for your patience and for joining us this morning. Let me just formally introduce our panel. We have Dr. John Knauss, the Under Secretary for Oceans and Atmosphere for NOAA, and he is accompanied by Mr. Gray Castle, the Deputy Under Secretary for Oceans and Atmosphere, and Mr. Thomas Pyke, the Assistant Administrator for Satellite and Information Services.

Gentlemen, we appreciate your being here. Dr. Knauss, we look forward to hearing from you.

STATEMENT OF DR. JOHN KNAUSS, UNDER SECRETARY FOR OCEANS AND ATMOSPHERE, NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, DEPARTMENT OF COMMERCE, ACCOMPANIED BY GRAY CASTLE, DEPUTY UNDER SECRETARY FOR OCEANS AND ATMOSPHERE; AND THOMAS N. PYKE, ASSISTANT ADMINISTRATOR FOR SATELLITE AND INFORMATION SERVICES

Dr. KNAUSS. Thank you, Mr. Chairman.

I have a full testimony which I would like, if possible, to be entered into the record and just briefly summarize.

Senator KERRY. Without objection, it will be entered in the record in full.

Dr. KNAUSS. As you noted, NOAA has a significant satellite program. In fact, I am told it is the fourth largest satellite operation in the world, following the Department of Defense, NASA, and the Soviet Space Agency. At present we have five operational satellites in orbit, one geostationary GOES satellite, two polar orbiters, and two Landsats. We also have a couple of other GOES satellites and one polar orbiter that we are using primarily as data communication links at present.

In fiscal year 1991, our budget for satellites is about $280 million. That is 20 percent, approximately, of the entire NOAA budget. So satellites are a significant part of the NOAA program.

My testimony centers on four broad areas. I would like to speak briefly on each of those areas. First is the geostationary observation we do with the GOES satellites. The second is our global atmospheric and oceanic observation programs with our polar orbiting environmental satellites. The third is our current responsibility for land observations under the Landsat commercialization program, and last is the processing, archiving, and distribution of environmental satellite data.

First, the GOES satellite. This is, as you pointed out, Mr. Chairman, the Nation's primary means of identifying and tracking severe storms. One example, was our tracking of Hurricane Hugo last fall; another example is the transmission of all those nightly TV pictures that you see about weather. That informaton comes from GOES satellites.

However, the GOES satellites also provide the data that are fed into our numerical models. They are important input to our daily weather forecasting.

Normally we have two GOES satellites in orbit, providing coverage from the coast of Africa to beyond Hawaii in the Pacific. But because of the premature failure of the early GOES satellites and

the loss of one GOES as it was being launched, we have only one functional GOES satellite at present, GOES 7. And GOES 7, unfortunately, was the last of a series.

Now, we have had some success in extending the life of the GOES 6. We did extend it for nine months beyond its normal design lifetime, and we are also conserving the fuel on board GOES 7 as well, to prolong its life. And we believe that we can extend the life of GOES 7 into 1993 if necessary before we run out of fuel, well over a year beyond its normal lifetime.

However, space is a hostile environment. These satellites are large, complex assemblies of mechanical components and they are subject to early failure. We have estimated that there is a ten percent chance of failure. In other words there is a 1 in 10 chance that the GOES 7 satellite will fail prior to running out of fuel.

It is also important to note that the GOES satellite replacement schedule is well behind schedule, as you noted. If development had gone as planned, the new GOES would have been up in 1988.

We have developed what we call a no-GOES contingency plan. It is a second best substitute, because no contingency plan using other satellites can completely and entirely replace the continuous GOES operation. This plan would mitigate the most severe consequences of a GOES data gap. We have tested the components and are continuing to test the components, and we are planning a full-scale test of the contingency plan this fall.

Why are we behind schedule? Because we began the GOES replacement plan in 1985. NASA contracted on NOAA's behalf to develop the GOES I through M, a new series designed to meet our requirements in the nineties.

These five satellites are being manufactured by Ford Aerospace, with ITT as the primary subcontractor of the remote sensing instruments. NASA administers this contract and provides the technical oversight for this operation, but it is funded through NOAA's budget, and there have been some major problems.

We, NASA, the contractor, all underestimated the difficulties in developing the improved sensing instruments, both the imager and the sounder. We in NOAA have agreed to a decrease in the capability compared to our original specifications. But we are still running far behind schedule, and when you run far behind schedule you get a large increase in the development costs.

This has been reflected in the NOAA budget. This is the first time NOAA has been involved in a developmental program for satellites and it is a bit of a shock to fund the budget overruns of the kind we have been having.

We in NOAA have made considerable efforts to address these problems, and so has NASA. NASA has convened teams of technical experts to help the contractors evaluate and correct the deficiencies. The situation is of great concern to us.

We are presently scheduled to launch the new GOES satellite in mid-1991. That will the first of our new series. However, it is possible that the launch may be delayed several months. This July NOAA and NASA are doing one of their periodic reviews, conducting a complete review to see if any change or any further delay of the satellite is warranted.

So much for the GOES. Let me take you next quickly to polar orbiting satellites. These are going very well. There has been some degradation in the performance of the two that are up there, NOAA 10 and 11, but that is to be expected as they age, and they are continuing to provide useful weather and global change data.

We may have a small future problem—at least I hope it is a small problem—because the launch of the next NOAA polar orbiter in this series has been delayed because NASA has determined that there is a design feature in this series that may pose a potential hazard to the launch pad personnel before it is launched.

But assuming we can get over this problem and, if necessary, do the necessary redesign work that is required—NASA will do the redesign work that is required—we have five other polar orbiting environmental satellites in production and scheduled to launch, and these will provide coverage in the late 1990s.

Furthermore, we have begun planning for the procurement of remote sensing instruments for these spacecraft that will follow those now in production for the next series.

Perhaps of special interest to this committee, I should note that we are discussing with the European Space Agency and the European Operational Meteorological Satellite Organization, EUMETSAT, the possibility of sharing the costs and the responsibilities for continuing environmental coverage into the 21st century.

The idea would be that the United States would be responsible for one of these polar orbiters and Europe would be responsible for the other. We have technical discussions under way on commonality of format, commonality of sensors, and so forth, and these ciscussions are going very well.

But I must note that no formal decision has yet been made about this decision to share resources.

Next, the Landsat. With the GOES and the polar orbiter there may be problems, but they are technical problems. Even with the GOES problems, we see light at the end of the tunnel. Landsat is a different kind of a problem. It is not a technical problem. There is no technical problem in Landsat.

But we have a major policy problem. Technically, both Landsat 4 and 5 are doing fine. In fact, they have long passed their design lifetime and they still seem to be going strong. However, either satellite could fail at any time.

The Administration, I wish to note, has committed to continued operation of Landsats 4 and 5 as long as they function. We are also continuing to fund the development of Landsat 6 and its planned launch, now scheduled for 1991, although I must note that that launch has been delayed by contractor spacecraft and instrument development problems.

I should further note, however, that under the Landsat commercialization contract there is a limit to the cost to the government for spacecraft development, so the costs of this delay and the corrections will therefore not be borne by the taxpayers.

Which brings me to the key Landsat problem from my perspective, the concept of Landsat commercialization. Our experience with the Landsat program and the results of the studies that we have had conducted for us by outside contractors have led us to the conclusion that commercialization of Landsat as had been original-

ly envisaged is not possible—we agree with Senator Pressler in that respect—at least not over the short term, and by "over the short term" I mean over a decade or perhaps two decades.

Landsat provides useful information to a variety of users, but all studies to date suggest that it is not yet, nor will it be over the short term at least, a viable commercial enterprise.

Finally, let me talk about the management of satellite data. It is one thing to get these satellites up in the air, but once they are there when the information comes down one must be able to manage that information. We in NOAA need to do more to ensure the long-term integrity and the quality of the data we collect.

We need to make that data more readily accessible to researchers and users. There is worldwide recognition of the fact that NOAA satellite data is crucial to the study of our environment. When I came aboard as NOAA Administrator, I made improving data management, not just satellite data, one of NOAA's top priorities. We must manage our data better.

We have an obligation to make our data available freely and openly. As what I call the Nation's Earth systems agency, NOAA has already taken major steps to improve the quality and accessibility of environmental data for which we are responsible. Future improvements are needed and they will be made.

We are committed to providing the scientific community with first class capability to access and use NOAA satellite data.

Thank you, Mr. Chairman. I will be happy to answer any questions you have. If I cannot, perhaps my colleagues on either side of me can.

[The statement and questions and answers follow:]

TESTIMONY
OF
DR. JOHN A. KNAUSS
UNDER SECRETARY OF COMMERCE FOR OCEANS AND ATMOSPHERE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE

Mr. Chairman and Members of the Committee:

Thank you for inviting me to testify this morning on satellite programs of the National Oceanic and Atmospheric Administration (NOAA), U.S. Department of Commerce.

NOAA environmental satellites have a key role not only in supporting our traditional weather forecasting mission, but also in providing critically needed environmental data that supports longer term global change research. Our polar orbiting and geostationary environmental satellites are essential primarily for weather warnings and for short and medium-range weather forecasting. At the same time, the complement of instruments that we carry on these satellites has evolved to provide a long-term, stable source of continuous observations from space of the atmosphere, the oceans, and the Earth's land surface.

As we plan for the space-based short-term Earth observing systems such as the planned NASA Earth Observing System, it is

important that we also put into perspective the value of NOAA's long-term satellite observations.

NOAA's satellite observations are validated by the data we acquire from our network of surface observing stations, observations taken in the atmosphere with radiosondes and aircraft and observations taken at sea with ocean buoys and ships. NOAA is also a focal point for the World Meteorological Organization and the International Committee of Scientific Unions in our worldwide effort to attain the free and open sharing of environmental data with other nations. Sharing of information is the only means we have to amass the critically needed global environmental observations that enhance short-term environmental forecasting and gain a better understanding of long-term global change.

I would now like to address NOAA's satellite activities in four broad areas: geostationary observations with GOES satellites; global atmospheric and oceanic observations with NOAA's polar orbiting environmental satellites; current responsibility for land observations under the Landsat Commercialization Program; and processing, archiving, and distribution of environmental satellite data. Let me first provide a summary of NOAA's FY 1991 satellite budget request.

NOAA's FY 1991 satellite budget request includes $109.1 million for geostationary systems, $64.6 million for polar

orbiting systems, $36.3 million for Landsat commercialization, and $48.2 million for environmental observing services.

The geostationary satellite system request is $26.9 million lower than for FY 1990, reflecting normal year-to-year fluctuations associated with the procurement and launch of GOES I through M.

The polar orbiting system request represents an increase of $49.4 million over FY 1990, reflecting normal year-to-year fluctuations for the costs associated with the procurement and launch of the NOAA D, I, J, K, L, and M satellites. It includes $3.5 million to start development of the remote-sensing instruments for the future polar system of the late 1990s and beyond.

For Landsat commercialization, an increase of $1.4 million has been requested. These funds will complete the construction and launching of Landsat 6.

The environmental observing services request, which covers the costs of operating all of our satellites, is $8.7 million below the FY 1990 level, reflecting the expectation that Landsats 4 and 5 will cease operating in 1990. If these satellites continue to function, we anticipate that funding will be sought to continue their operation consistent with the President's policy of seeking to maintain continuity of Landsat-type data.

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NOAA's geostationary operational environmental satellites (GOES) provide the Nation's primary means of identifying and tracking severe storms that may affect the United States and other parts of the world. Their data provide weather forecasters with the information they need to issue accurate advisories and warnings on a timely basis.

As you know, we normally have two GOES satellites with an operating imaging and sounding capability that together provide broad coverage from the coast of Africa, where Atlantic hurricanes are spawned, to views beyond Hawaii in the Pacific. Because of premature failure of early GOES satellites and the loss of one GOES as it was being launched, we find ourselves currently with only one fully functional GOES satellite, GOES 7. We were successful in extending the life of GOES 6 by 9 months beyond its nominal designed lifetime through careful management of onboard fuel and observing systems. We have taken special steps to conserve onboard fuel on our current GOES 7 to prolong its life. Although space is a hostile environment, and these satellites are large, complex assemblies of electronic and mechanical components subject to possibly early failure, the steps we have taken give us the opportunity to extend the life of GOES 7 into 1993, which is well beyond its design lifetime. There is, however, an estimated 10 per cent chance that GOES 7 will fail prior to 1993.

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In 1985, NASA contracted on behalf of NOAA for the development of GOES I through M, a new series of geostationary environmental satellites designed to meet our requirements in the 1990s. These five new satellites are being manufactured by Ford Aerospace Corporation, with ITT as the primary subcontractor for development of the remote-sensing instruments. NASA administers this contract and provides technical oversight of spacecraft and instrument development.

There have been major problems in development of these new satellites. In particular, the development of the primary remote-sensing instruments, the imager and the atmospheric sounder, has proven to be much more difficult than originally anticipated by the contractors, NASA, and NOAA. Although NOAA has agreed to a decrease in capability compared to original specifications, the contractors are running far behind schedule. We are projecting, as a result, a large increase in GOES development cost which is reflected in the NOAA budget.

Two years ago, NOAA managers directed that extraordinary measures be taken to address continuing technical developmental problems with these new GOES instruments. NASA has convened teams of technical experts to help the contractors evaluate and correct technical deficiencies. This contract is of great concern to us as we address our basic requirements for GOES data and seek to avoid a no-GOES situation if at all possible, while we do what we can to contain contractor costs.

At the same time, NOAA has developed a no-GOES contingency plan. Although no other observing system can entirely replace the continuous observations from GOES, this plan would mitigate the most severe consequences of a GOES data gap. A full test of this contingency plan is scheduled for this fall.

We have agreed with NASA that we will continue to press for a mid-1991 launch of GOES I, the first in this new series of spacecraft. However, the time which may be required to resolve current technical problems may necessitate a launch delay of up to several months. This summer NOAA, with NASA, will conduct a complete program reassessment to determine if launch schedule or other changes are warranted.

NOAA's polar environmental satellites provide valuable data not only for weather forecasting, but also for supporting global change research. The two primary operational polar satellites, NOAA 10 and NOAA 11, have both experienced some degradation in performance as they have aged. The launch of NOAA D, the next in this type of spacecraft, has been delayed because NASA has determined that a design feature in this series of spacecraft may pose a potential hazard to persons on the launch pad.

Five other NOAA polar environmental satellites are in production and scheduled for launch. These will provide coverage into the late 1990s. We have begun planning the procurement of remote-sensing instruments for these spacecraft that will follow

those now in production. We are discussing with the European Space Agency and the European operational meteorological satellite organization, EUMETSAT, the possibility of sharing responsibility and cost for continuing operational polar environmental coverage on an international basis in the late 1990s and into the 21st Century. The Europeans are interested in taking on the responsibility for the morning polar mission, while NOAA would continue to provide afternoon coverage. We are exploring all feasible opportunities for cooperation with other domestic and foreign Government agencies and are looking at new technologies that may help NOAA to conduct its future polar environmental program more effectively and economically.

Turning to the Landsat Commercialization Program, both Landsats 4 and 5 passed the end of their design lifetimes long ago. Either satellite could fail at any time. The Administration has commited to continued operation as long as they function.

We also continue to fund the development of Landsat 6 and its planned launch, which is now scheduled for December 1991. That launch has also been delayed by contractor spacecraft and instrument development problems. Under the Landsat Commercialization contract there is a limit on the cost to the government for spacecraft development. The costs of this delay and the corrections that are needed will therefore not be borne by American taxpayers.

Our experience with the Landsat program, and the results of studies conducted for us, have led us to the conclusion that commercialization of Landsat, as had originally been envisioned, is not possible.

I would like to bring to your attention the Administration proposed legislation transferring the authority for land remote sensing data archiving from Commerce to the Department of the Interior. The proposal, which has been introduced in both Houses (H.R. 2873 and S. 1307), was included in House-passed H.R. 2427. I urge prompt passage of the Administration's proposal by the Senate.

Finally, let me address NOAA's management of its satellite data. NOAA provides data in real-time to the National Weather Service and to the meteorological services of over 120 other nations. We also provide a wide-range of near real-time derived products, such as atmospheric soundings, sea surface temperature, global vegetation index, and global stratospheric ozone, as well as search and rescue alerts to the Air Force and the Coast Guard from the NOAA operated U.S. Mission Control Center for the global satellite-aided search and rescue system.

Although we have carefully preserved the data from our geostationary and polar orbiting spacecraft, we are increasingly conscious of the need to do much more to assure the long-term integrity and quality of these data and to make data more readily accessible. Of special concern is the worldwide recognition that

the data from NOAA satellites are critical to the study of change in our environment. As a earth systems agency, NOAA has already taken major steps to improve the quality and accessibility of the environmental data for which we are responsible, and we are planning major improvements in the future. Our FY 1991 budget request for climate and global change, for example, includes an increase of $17 million to improve our present environmental data system, to handle the large anticipated increase in the volume of data that we acquire and control. We are committed to providing the scientific community with a first-class capability to access and use NOAA's satellite data and all other data for which we are responsible.

I assure you that NOAA's concern for environmental data is a top priority. The Nation and the world turns to NOAA for high quality, readily available environmental data. We are improving our data management capability to respond to that need.

In closing, I will comment briefly on the FY 1991 NOAA budget estimates for the National Weather Service (NWS) and the Oceanic and Atmospheric Research (OAR) programs.

Climate and Global Change

The FY 1991 request includes $87 million, an increase of $69 million, to support NOAA's contribution to the U.S. Global Change Research Program. NOAA's Climate and Global Change Program is a vital component of the U.S. effort and enables the agency to

bring its unique talents and special capabilities to bear on some of the highest priorities identified by the Committee on Earth Sciences (CES). Consistent with CES priorities, NOAA has chosen to focus on changes in the Earth's climate system that confront us with major economic, social, and environmental challenges. The President's Fiscal Year 1991 Budget emphasizes the need to improve our understanding of processes such as greenhouse warming, ozone depletion, regional drought, water resources, and year-to-year climate change.

NOAA is prepared to assume long-term responsibility, in concert with other agencies and the broad scientific community, for presenting authoritative information on global environmental change in a form useful to decision-makers. NOAA's mission and expertise have led us to assume responsibility as a principal operational climate prediction and information service agency in the national program.

The commitment to establish the aggressive scientific program outlined by NOAA and the CES agencies is a significant policy decision that recognizes the need to improve our understanding of the Earth system, reduce major scientific uncertainties in the decision process, and continuously reevaluate the effectiveness of policy in the light of new scientific insight.

Specifically, NOAA's Climate and Global Change Program budget for FY 1991 will enable NOAA to focus upon:

- o DOCUMENTING GLOBAL CHANGE, with particular focus on operational ocean observations, global sea level, stratospheric ozone, climate diagnostics, and the establishment of an effective NOAA and national global environmental sciences data and information management system.

- o FOCUSED PROCESS STUDIES aimed at scientific priorities identified by CES, including the role of the ocean in climate change, clouds, water vapor and the hydrological cycle, the response of marine ecosystems to climate and related stresses, and the sources, sinks, and behavior of greenhouse gases.

- o CLIMATE MODELLING AND PREDICTION, including operational ocean modelling, improvement of operational predictive capabilities on monthly and seasonal timescales, and the design and implementation of an effective multi-agency approach to climate prediction on interannual and decadal timescales.

Weather Service Modernization

Another highlight in our budget request is the continuation of the National Weather Service modernization. First of all, I am pleased to assure you that our request contains sufficient funds to maintain all existing public warning and forecast stations in 1991. Secondly, the budget requests $76.5 million over FY 1991 base funding for the systems necessary to implement the modernization.

Keeping the modernization of the National Weather Service on schedule is one of my highest priorities. The state-of-the-art systems we are acquiring will enable us to observe, with higher space and time resolution, the weather conditions over the United States.

The 1991 budget requests a $43.3 million increase for Next Generation Radar (NEXRAD). By October 1991, eleven of these enhanced doppler radars will be delivered. Secondly, the budget requests a $5.4 million increase for the Automated Surface Observation System (ASOS), to continue the full-scale production contract which will be awarded in August 1990.

Thirdly, the budget requests a $21.4 million increase for the Advanced Weather Interactive Processing System (AWIPS). These funds will allow us to proceed with technology development and prototype deployment at the Modernization and Associated Restructuring Demonstration (MARD) sites. The budget also requests a $7 million increase for NOAAPORT to enhance GOES data remapping and data communications capabilities.

In addition, the budget contains an increase of $11 million for the Modernization and Associated Restructuring Demonstration and Implementation (MARDI). This is a key element of the modernization program, as it will demonstrate the new technology and service improvements, provide professional development for NWS Staff, and implement the service improvements at selected weather forecast offices in the Central Plains States.

NOAA Atmospheric Research

NOAA's atmospheric research program supports the modernization of weather and solar terrestrial services. This research effort contributes to mitigation of human and economic

losses due to natural hazards, while developing a critical body of information crucial to well-informed policymaking on environmental issues. For example, the Nation is becoming increasingly dependent upon sophisticated electronic and other systems which can be affected by solar and geomagnetic activity. In March 1989, major solar flares and their resultant geomagnetic storms caused:

- Some NASA satellites in low-earth orbit to lose altitude abruptly;
- Some NOAA satellites in low-earth orbit to experience difficulty in maintaining altitude;
- Computer upsets in commercial spacecraft; and
- Loss of power to six million people in Quebec.

In the President's FY 1991 budget, NOAA is requesting an increase of $1,500,000 to acquire and analyze solar-terrestrial data from new sources to provide improved forecasts and warnings of solar disturbances. The services, improvements, and research outlined in this initiative will enable NOAA to provide reliable forecasts and monitoring that will allow for preventive actions.

Thank you for this opportunity to provide this Committee with a status report on NOAA satellite and related programs. I will be pleased to answer any questions you may have.

QUESTIONS OF SENATOR PRESSLER AND THE ANSWERS THERETO

Mr. Secretary, in your opinion, has Landsat commercialization worked out very well?

Our experience with the Landsat program, and the results of studies conducted for us, have led us to the conclusion that commercialization of Landsat, as had originally been envisioned, is not possible in the next decade. These studies, commissioned by the Department of Commerce at the request of Congress, concluded that a private sector entity would need substantial Government subsidies to cover the capital costs of a civil land remote-sensing system.

We have Landsat 4 and 5 up there now. We don't know how long they'll continue, but there's no outward sign that they're going to stop in the next year. Landsat probably won't be operational until 1992. Are we going to have funds to operate it and where will the funds come from?

It is the Administration's position to continue Landsat 4 and 5 operations at least until Landsat 6 becomes operational. The Earth Observation Satellite Company (EOSAT) has recently completed an engineering analysis at the request of NOAA which indicated that these satellites should continue to operate for a significant part of FY 1991. We anticipate receiving funding for Landsat 4/5 operations in FY 1991 from those Federal agencies that are substantial users of Landsat data. This is how Landsat 4/5 operations are currently being funded. Funding for Landsat 6 operations, on the other hand, will be completely the responsibility of EOSAT.

Assuming there is going to be a "Landsat 7", when should we start budgeting design and start up money to get the process going?

The future of the acquisition of Landsat-type data beyond Landsat 6, including consideration of schedule and funding issues, is under review by the Administration.

How widely is this (Landsat) data being used? It has been my understanding that the actual number of products being used by Universities, scientists and other research institutions has dramatically declined. Do you keep numbers on that?

The U.S. Geological Survey's Earth Resources Observation Satellite (EROS) Data Center has reported the following Landsat sales figures from "Academia." The number of items, which include both photographic and digital products, has dropped significantly during the last decade.

FISCAL YEAR	ITEMS SOLD
1980	12,977
1981	11,401
1982	7,753
1983	5,688
1984	2,578
1985	2,545
1986	784
1987	847
1988	854
1989	579

If we do away with the Landsat commercialization concept and decide to fund Landsat as a public sector program, would you be opposed to transferring operation and management of that program to a user agency such as the Department of the Interior?

The Department of Commerce would not be opposed to transferring responsibility for the program to a Landsat user agency capable of managing the program.

How much have we spent -- both direct expenditures and government subsidies -- since commercialization of the Landsat program?

Since September 1985, when the contract was signed with EOSAT, the Government will have spent $337.1 million through the end of FY 1990 to operate Landsats 4 and 5 and to develop the Landsat 6 spacecraft and ground system.

The National Space Council has recognized the fundamental importance of Landsat technology and has committed to continuation after Landsat 6.

In light of the fact that Landsat Commercialization has (sic) been and will not be successful, what are NOAA's plans for continuation of the program after Landsat 6?

The future of the acquisition of Landsat-type data after Landsat 6 is under review by the Administration.

Do you plan to be active in pursuing operations funding for Landsats 4 and 5?

It is the Administration's position to continue Landsat 4 and 5 operations at least until Landsat 6 becomes operational. We anticipate receiving funding for Landsat 4/5 operations in FY 1991 from those Federal agencies that are substantial users of Landsat data. This is how Landsat 4/5 operations are currently being funded.

With regards to the proposed NEXRAD system in South Dakota, what are you doing to ensure that there will be no degradation of weather service in South Dakota? What is your definition of "degradation of weather service" as stated in PL 100-685, and how is that provision being guaranteed? Also, who defines whether or not there has been a "degradation of weather service?"

As discussed at the public meeting in Huron, some Weather Service Forecast Offices (WSFO) and Weather Service Offices (WSO) throughout the Nation will be closed as a result of consolidation. Before closure of a WSFO or WSO, the Secretary of Commerce, under the 1988 Public Law 100-685, must certify to the Congress that modernization and associated restructuring of the National Weather Service (NWS) will not degrade, or lower the quality of, essential weather services, including those pertaining to public safety and emergency preparedness.

The Secretary's certification will be supported by a multisite operational demonstration of the modernized and restructured NWS. Effectiveness of the newly deployed technologies, including the Weather Surveillance Radar-88 Doppler (WSR-88D) now being procured under the Next Generation Weather Radar (NEXRAD) program, will be demonstrated. The National Research Council of

the National Academy of Sciences will provide technical assistance in developing plans for the demonstration and its subsequent evaluation.

Weather services both before and after closure of a WSFO or WSO will be compared in detail, and improvements in service resulting from recent or expected modernization of NWS operations will be identified and enumerated. Before and during the certification process, the NWS will coordinate with the appropriate state and local officials. Each fiscal year a National Implementation Plan, which specifies near-term changes and updates long-term proposals, will be submitted to the Congress.

According to the map on page 12 of the National Weather Service's "Strategic Plan of the Modernization and Associated Restructuring of the National Weather Service" (attached), there is a grey area in southern South Dakota which lacks coverage by the NEXRAD system. From my point of view, the NEXRAD program is leaving a large "hole" in South Dakota uncovered and is planning to close the very office and remove the very people who currently serve the area the NEXRAD may leave uncovered. To me, and to the people living there, that looks like a "degradation in service." Explain why the National Weather Service feels otherwise.

The NWS is firmly committed to provide improved weather radar coverage for all communities in South Dakota, including those in the south-central area consisting of Tripp and Lyman Counties. Existing coverage over this area is based upon the reflectivity capabilities of the Huron weather radar, an obsolescent unit more than 30 years old. Future coverage will be based upon the superior reflectivity capabilities of the WSR-88D with its more powerful transmitter, more sensitive receiver, more precise beam, advanced algorithms, and faster data processing systems.

The WSR-88D's reflectivity range is 460 kilometers or about 288 miles. Tripp and Lyman Counties will lie about 144 to 185 miles -- well within reflectivity range -- from the WSR-88D sites at or near North Platte, Aberdeen, Sioux Falls, and Rapid City. The radar beams from these sites will regularly scan as low as 11,000 feet, 11,500 feet, 13,000 feet, and 14,000 feet, respectively, over Winner, the area's most populous community. For severe storms typical of the midwest, the strongest radar signatures occur between 10,000 and 20,000 feet above ground level. Throughout the reflectivity range, data pertaining to precipitation and atmospheric stability will be significantly more detailed than currently available. The WSR-88D's superior ability to penetrate intervening weather phenomena and its far

greater sensitivity to weaker signals at all ranges will enable it to identify light rain, fine drizzle, mist, snow, and other phenomena seldom or poorly detected by current radars.

The WSR-88D's Doppler capability, for which the range is 230 kilometers or about 144 miles, will enable it to detect variations in wind speed and direction. Areas which surround Tripp and Lyman Counties will lie within Doppler, as well as reflectivity, range of the planned radar sites. Thus, for severe storms which approach south-central South Dakota through surrounding areas, both Doppler and reflectivity data will be generated.

Furthermore, the NWS's ability to provide quality weather services to south central South Dakota is not based solely on the deployment of enhanced doppler radars. The WSR-88D is one of several weather surveillance and data processing technologies scheduled for deployment in this decade. NWS modernization will include the Advanced Weather Interactive Processing System (AWIPS), which will provide rapid, computerized integration of digital data from many sources; geostationary satellites; Automated Surface Observing Systems (ASOS); improved global and long-term forecasting capabilities at the National Meteorological Center (NMC); and better equipped field offices. It is the combination of these improved surveillance technologies and forecasting techniques that will provide South Dakota, and the Nation as a whole, with improved weather services.

Are there any confirmed statistics stating the actual abilities of NEXRAD? More specifically, what is NEXRAD's total scanning capabilities -- the circumference?

During operational testing of the WSR-88D preproduction model at Norman, Oklahoma, from March to August 1989, excellent reflectivity data were demonstrated out to 460 kilometers or about 288 miles, while Doppler data were effective out to 230 kilometers or about 144 miles. At these ranges, detection performance and quantitative measurements were highly accurate. During the 5-month performance trials, the accuracy of severe storm warnings was significantly higher than the current national average (91 percent versus 58 percent), while the false alarm rate was much lower (21 percent versus 57 percent).

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In the event that NEXRAD does not possess adequate scanning capabilities, how do you expect to ensure public and aviation safety? The area I am particularly concerned about is located south of Pierre (our state capitol), which your current map shows is covered.

The enclosed chart is a radar coverage analysis for South Dakota. It delineates the areas which the WSR-88Ds, located in and around the state, will cover at altitudes up to 10,000 feet, based upon the radar's performance characteristics, surrounding geographic features, and the earth's curvature. These delineated areas closely approximate the Doppler-based coverage to be provided by the planned WSR-88D sites. As you have noted, Pierre and the area immediately southward lie within Doppler range of both the Aberdeen and Rapid City radar sites.

Though not shown, areas of reflectivity-based coverage will be considerably larger, since the reflectivity range is generally twice the Doppler range. The entire state, including the south-central counties of Lyman and Tripp, will receive reflectivity-based coverage superior in quality to what is now available. Nearly all of the state, as indicated on the chart, will receive Doppler-based coverage, a capability that is now unavailable.

The WSR-88D and complementary technologies, such as ASOS, geostationary satellites, and upper air balloon launches, will support an improved public and aviation forecast and warning program.

Some argue that NEXRAD is incapable of detecting tornadoes which are scaled as being less than a F5 tornado. How do you propose to offer vital information to the areas that experience tornadoes other than a large-scale F5 tornado?

An important objective of NWS modernization is to increase warning lead times by advance detection of conditions, such as mesoscale mid-level circulations within severe thunderstorms, which typically precede the formation of major tornadoes. Current weather radars lack this ability and can detect tornadoes or funnel clouds only after they have formed. With this limitation, forecasters generally cannot issue a warning until a tornado has already contacted the ground and is causing damage. Doppler weather radars, such as the WSR-88D, are designed to detect the rotation within severe storms that have been observed to precede tornado formation. These precursor rotations are larger than tornadoes themselves and are detectable out to

150 kilometers (about 92 miles). By detecting these precursor events, forecasters can issue warnings before tornadoes actually occur, thereby increasing lead times significantly.

The WSR-88D's beam width is approximately one half that of current radars and will enable the WSR-88D to detect significantly smaller phenomena at greater distances. Nearly all fully formed tornadoes within 80 kilometers (about 50 miles) of the WSR-88D will be detectable. Even farther out to 110 kilometers (about 69) miles, detection of the stronger, more destructive F3, F4, and F5 tornadoes will be significantly more reliable than with current radars. Beyond this distance, as the radar beam gradually widens, thereby decreasing its ability to resolve smaller phenomena, and as the earth's surface curves farther away, direct tornado detection becomes correspondingly less probable. Some small tornadoes of F0 and F1 strength, occurring very close to the earth's surface below the radar beam, can escape detection, no matter how sophisticated the radar may be. To identify and track all smaller, less intense tornadoes everywhere would require a network of radars so densely spaced as to be economically infeasible.

Because many small and medium sized cities will not benefit from the acquisition by the NWS of Doppler technology due to their distance from planned radar sites, what does the NWS plan to do to sustain quality service to these areas?

It is untrue that many small and medium cities are too distant from the planned radar sites to benefit from the NEXRAD technology. NEXRAD will enable the NWS to improve coverage provided by the conventional radar network by providing greatly expanded reflectivity coverage throughout the Nation. In addition to this fundamental improvement, NEXRAD incorporates Doppler technology into the NWS' surveillance capabilities. Once the WSR-88D units and their associated Weather Forecast Offices (WFO) are deployed as a fully integrated network, the area of warning responsibility for each WFO will be configured according to the coverage provided by its associated WSR-88D. Direct telecommunications links will enable the forecasters at a given WFO to access digital data from adjacent radars, as well as their own. A storm approaching a small community like Winner through the Rapid City coverage area could be monitored by the Sioux Falls office. In this way, multiple views from adjacent radars will be available to help detect and track severe weather disturbances.

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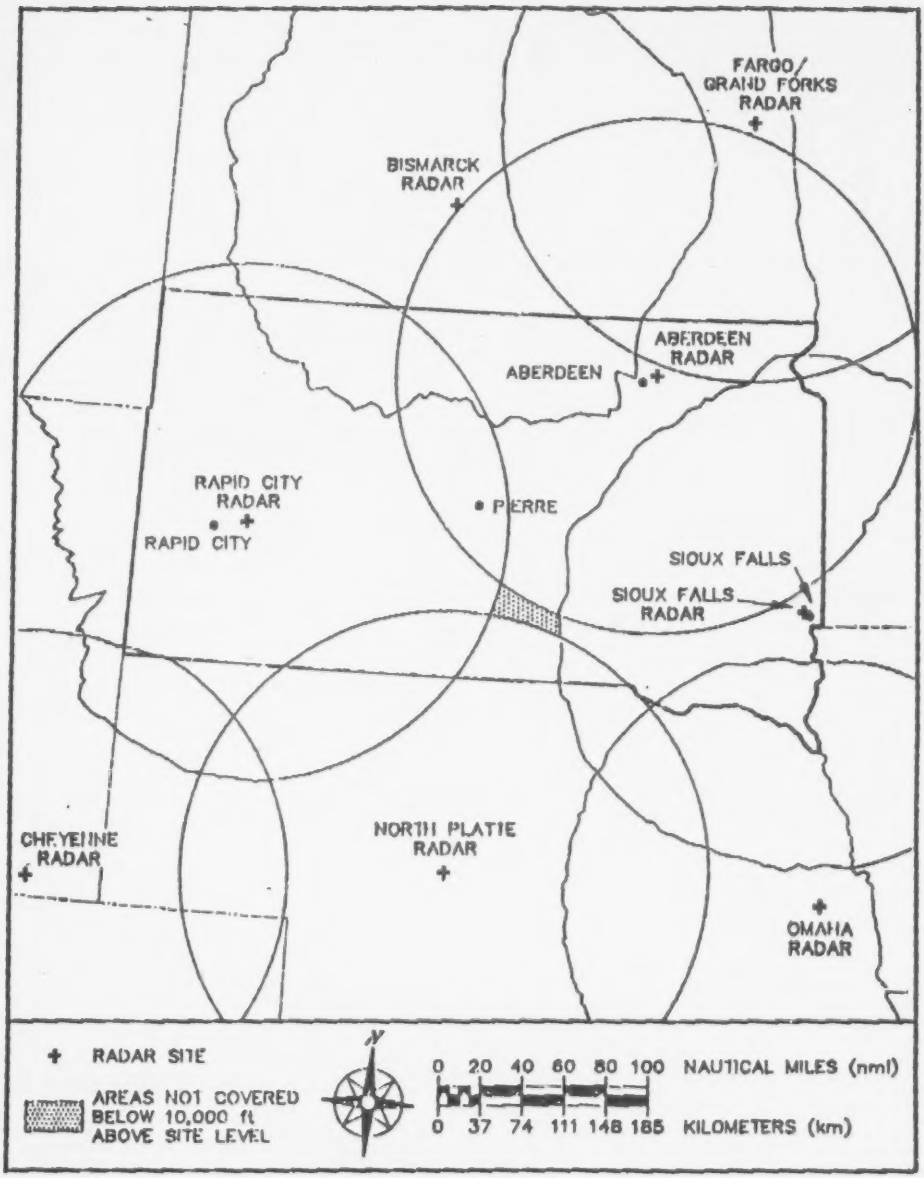
Because every NEXRAD will have an associated WFO (each WFO being nearly identical) how do you propose to manage the problem of varying precipitation patterns, temperatures and topography across the country? These are just a few of the numerous variables to take into account. User communities are uniquely different. The population of each WFO area differs as does the area served by each WFO.

Under the modernization and restructuring plan, South Dakota will be served by 61 NWS personnel consisting mostly of professional meteorologists. The state is currently served by a 54-member staff consisting mostly of paraprofessional and support personnel. A typical WFO will be staffed by a meteorologist in charge, a science and operations officer, a service hydrologist, ten duty meteorologists, five hydrometeorological technicians, and computer and electronics technicians. Each WFO staff will also include a warning coordination meteorologist whose primary responsibility will be to work closely with state and local governments, emergency management agencies, the agricultural community, fire fighters, aviators, the news media, the public, and volunteer spotter networks, such as Skywarn.

Extensive training programs in the newly deployed technologies, along with stringent professional and educational standards commensurate with the NWS's many hydrometeorological missions throughout the country, are now being programmed for NWS technical personnel. Through close association, training, and experience, the WFO professional staff will be thoroughly versed in the special needs of the communities which they serve and in the conditions unique to their area of responsibility. Within general guidelines, warning and forecasting services can be customized as needed. For each warning area, computer algorithms used to process and display weather radar data will include the area's climatological and topological parameters. The AWIPS will integrate data from the WSR-88Ds, ASOS, the NMC, and satellites to help each WFO prepare warnings and forecasts specifically for its area of responsibility.

ATTACHMENT



NEXRAD COVERAGE OF SOUTH DAKOTA AT 10,000 ft
(Doppler)

Senator KERRY. Thank you very much, Dr. Knauss.

Let me, before I begin a round of questioning, ask Senator Gore, who has joined us, if he has any opening comments he would wish to make.

OPENING STATEMENT BY SENATOR GORE

Senator GORE. Thank you very much, Mr. Chairman.

As chairman of the space subcommittee, I and my colleagues there have pursued issues that are sister issues to the ones under discussion here today, and I look forward to my opportunity to ask questions here.

I might just say very briefly, by way of an opening comment—and I understand Senator Pressler expressed some views before I arrived with respect to the commercialization of Landsat—that I welcome your statement just now, which represents a conclusion on the part of NOAA that the commercialization of Landsat, at least as presently conceived, is simply not possible.

I and some others have been saying that for a number of years now. It appeared to me to be a nonsensical proposal when it was first made. This debacle—and that is what it is, it is a policy debacle for Landsat—was predicted, it was expected. It does not come as a surprise to many who saw it coming.

So I welcome the forthright statement you have made this morning. I note that it was not followed by another forthright statement as to what the Administration now plans to do about Landsat, since its policy is now acknowledged to be a complete failure, what alternative is going to be proposed to continue collecting images by way of Landsat.

Mr. Chairman, there is a value in the continuity of a record, once it is started. Scientists who can use the same kinds of images over an extended period of time to analyze changes in the Earth's surface, and changes of other kinds available through Landsat imagery, find the prospect of discontinuing that record just at the time when global change is accelerating in its pace and intensity to be a prospective tragedy for all who want to document these changes and help to improve our understanding of what is happening and how we can respond to it.

So we now know we are in agreement that the commercialization policy is a failure. We are not yet in agreement, I take it, that Landsat should continue. And I find that surprising.

I know what your private views probably are, Dr. Knauss. I have not talked with you about it, but I suspect I know what your private views are.

I do not know what the Administration's official views are on whether Landsat is worth continuing and whether it is willing to make a commitment to Landsat as a program of this government now that commercialization is acknowledged to be a failure.

I will pursue that in my questions in the first round shortly.

Thank you, Mr. Chairman.

Senator KERRY. Thank you very much, Senator Gore. I appreciate your observations, which are, as usual, right to the point and important in the context of our overall satellite program.

Let me just announce, which I failed to do at the outset, that it is my intention to introduce and press for action on a comprehensive NOAA authorization bill very shortly. This bill will include not only the satellite and atmospheric programs that we are talking about right now, but also the National Weather Service programs, the coastal monitoring program, the ocean and coastal programs, the routine fisheries programs authorization, and the NOAA program support activities. So we hope to proceed forward on that assumption.

Dr. Knauss, I want to thank you for your candid assessment. With candor there always comes, obviously, the stark reality that you have got to confront some problems, but that is important and that is why we are here.

You have already discussed and laid out your testimony in the context of four areas: the GOES program; NOAA's polar orbiting program, which I gather has a NOAA D problem that may pose a launch pad hazard, but other than that seems to be on schedule if I am correct; the Landsat program, which now two of my colleagues have addressed and about which you have acknowledged the problems; and the issue of the gathering and dissemination of information.

It seems as though in all four areas we unfortunately are confronting problems, and a couple of them very serious ones, in the context of where we would like to be in maintaining the ability of NOAA's satellite systems to meet our information requirements.

Before I get specific in my questions, let me ask you, is it your sense that we are stuck in this position? Can we surmount the problems in these four areas? Is there some way in which the Administration and the Congress can join together to redirect our energies and get a handle on these problems?

Dr. KNAUSS. Well, Senator, I am more optimistic than that. We have had very difficult problems with the GOES satellites, which we acknowledge. We are hopeful that at least we know what the problems are. We are hopeful that we are on our way to completion of the GOES satellite program. It is behind schedule, but we expect that the problems are being solved, and it will be launched.

We presently, as I indicated, have a launch date of midyear next year. I am personally concerned that it may slip a few months, but I do not think it will slip more than a few months.

I like to think that I see light at the end of the tunnel with respect to the GOES issue, sir.

With respect to the Landsat, it is indeed a policy issue which must be addressed. It is being addressed. And as far as the environmental management of the data is concerned, I can assure you, sir, we are addressing that issue within NOAA at present.

At this point it is our estimate that, although all NOAA data is available, something less than 50 percent of it is easily available. My goal is to make 90 percent of that data easily available within the next 5 years, and we have set in motion a program to do just that.

Senator KERRY. Now, in your testimony you say the following:

Two years ago, NOAA managers directed that extraordinary measures be taken to address continuing technical development problems with these new NOAA in-

struments. NASA has convened teams of technical experts to help contractors evaluate and correct the deficiencies. The contract is of great concern to us.

And then: "As we seek to avoid a no-GOES situation if at all possible." Can you tell the committee what you mean by "if at all possible"? What odds are we looking at here? Where are we in terms of the possibility of a no-GOES situation?

Dr. KNAUSS. Well, as I indicated in my testimony, we feel that if we can manage the present GOES 7 that we have up there, it will last into 1993. I cannot imagine our difficulty with the new series of GOES will go on that long. We will certainly have a GOES up there well before 1993.

However, things do go wrong with satellites that are in orbit, for unusual reasons—solar storms and other kinds of things. Our engineering studies have suggested that we have approximately a ten percent chance of an unusual thing happening, a failure. So I would say we have a chance of one-in-ten losing it, of being in a no-GOES situation.

And that is why we have instituted what we call this contingency plan, where we are going to be using our polar orbiters and essentially to take the images from them and reformat them so that they in some way approximate the kind of information one gets from a geostationary satellite. It is not the same thing by a long shot, but at least it mitigates some of our most difficult issues that we will be facing.

Senator KERRY. Is that the contingency plan that you referred to in the testimony?

Dr. KNAUSS. That is the contingency plan, yes.

Senator KERRY. That will not be tested until this fall, right?

Dr. KNAUSS. We are testing components of it all along. We are going to go into a full-scale test of it as soon as we are ready, which we think will be late summer, early fall.

Senator KERRY. So between now and then, do the odds of a failure remain 10 percent?

Dr. KNAUSS. Approximately 10 percent, I am told.

Senator KERRY. Approximately 10 percent. What are the implications of a no-GOES situation? What is the down side?

Dr. KNAUSS. Well, we must remember that it was not too many years ago when we were forecasting weather without GOES. So we clearly are going to be able to manage, to provide weather forecasts. Clearly, the information that goes into our models will be less complete. I suspect there will be slight degradation in our forecasting precision and accuracy.

My guess is the major problem without the GOES is the inability to see the hurricanes and the things out in the ocean quickly and regularly. Before we had the GOES satellites, those were sometimes missed. But I think with the polar orbiters we clearly will not be able to track them anywhere near as well, but we are not going to miss seeing them.

So we will be able to track them, but we will not be able to provide the kind of precision of where they are, how fast they are moving, when they will hit the coast. For example, we did an excellent job with Hurricane Hugo in saying when it would hit and where it would hit, and without a GOES I suspect that that kind of precision will be degraded.

Senator KERRY. The 1984 estimate for the series of GOES I through M, I believe, was $294 million.

Dr. KNAUSS. Yes.

Senator KERRY. And now we are up to about $750 million, and we may be faced with further cost increases. Is that accurate?

Dr. KNAUSS. Mr. Pyke?

Mr. PYKE. Mr. Chairman, the $294 million is not quite on a parallel with the $700 million number. A better estimate of the total cost for five new GOES satellites is on the order of $500 million, and that is based on NASA's early estimate of what the eventual total cost would be for the five spacecraft.

Dr. KNAUSS. But the final cost is correct.

Senator KERRY. The final cost——

Dr. KNAUSS. I mean, the final cost that you indicated is what we are now paying, yes.

Senator KERRY. That cost is now what you are using for planning purposes?

Dr. KNAUSS. Yes.

Senator KERRY. OK. Are we going to anticipate adjustments to the 1991 budget request?

Dr. KNAUSS. Until we have done our July review, I am not in a position to give a formal response to that, sir.

Senator KERRY. Are you confident at this point in time—maybe your answer to that question says you are not—that adequate steps have been taken to control procurement costs?

Dr. KNAUSS. We have done a lot to try to do this. I think we have done the best job we can. Mr. Castle here has spent a large part of his time since he has come aboard NOAA looking at this issue, and perhaps he can tell you a bit more what we have done in this matter.

Mr. CASTLE. We are spending a great deal of time on both technical problems and costs. It must be kept in mind this is a developmental project, and it is much more difficult to control costs in a development program, where you are stretching the state of the art, than it is on just manufacturing widgets, and that is part of the problem. It has been part of the problem since the beginning.

Senator KERRY. Part of which problem?

Mr. CASTLE. Part of the cost problem from the beginning. This has been a very ambitious project, technically.

Senator KERRY. Well, maybe that is the problem. I mean, we had a GOES design up there that was working and performing the responsibilities, and the objective is to maintain the coverage. Why was the decision made to push the technology so far beyond our capabilities?

Dr. KNAUSS. In hindsight, sir, you are absolutely correct. We—the experts in NOAA, in NASA, and the contractors, thought that what we were trying to do was a relatively small incremental step in development, because there clearly are a number of reasons for wanting to have better information that we will get with this new satellite.

Mr. CASTLE. And the good news is that we believe now that we have identified the last of the major problems, and that there is a much better chance now than there was 3 months ago or 6 months

ago to have a specification-compliant spacecraft which can be launched in the vicinity of the June 1991 scheduled launch date.

Senator KERRY. Well now, the current GOES launch schedule that you are planning on is, I think, based on a 5-year replacement interval; is that correct? Which I gather does not take into account the possibility of a launch failure. And yet, having had the experience of launch failures, shouldn't there be some contingency with respect to that possibility?

Mr. PYKE. Yes. The current launch schedule, other than the arrangement at the beginning to have the first two launches fairly close together in order to get us back into a two-GOES situation, after that time the launch schedule calls for each spacecraft to be replaced at the end of its design lifetime.

The spacecraft will be produced in such a way that they will be available earlier than the scheduled launch dates, especially for the later launches. And should an emergency situation arise late in this decade, we would have to revisit the issue of the schedule for launches at that time. But at this time, what we are planning for and what we are assuming is a full, 5-year or better lifetime for each of these spacecraft.

Senator KERRY. If there were a launch failure, the contractor pays for the launch vehicle, is that correct?

Mr. PYKE. Yes, sir.

Senator KERRY. Who will pay for the replacement satellite cost?

Mr. PYKE. This is a commercial launch services contract that NASA has on our behalf, and it has a provision in which on launch failure, as you say, if there were a launch failure, the launch services contractor would provide a relaunch at no cost to the government.

Senator KERRY. Would that include the satellite itself?

Mr. PYKE. No, sir. We would simply use one of the other five spacecraft that we have for that next launch in that case.

Senator KERRY. What would be the time interval for launching the replacement satellite?

Mr. PYKE. I would say, barring other circumstances, on the order of 3 or 4 months, once we are well along in production with the spacecraft and once we have gotten to the so-called call-up provisions of the launch services contract, in which we can ask for a launch with relatively short advance notice.

Senator KERRY. I have a number of other questions, but I will now turn to Senator Gore.

Before I do, let me just ask one more question. In your testimony on page 8 you say: "We are increasingly conscious of the need to do much more to ensure the long-term integrity and quality of this data and to make data more readily accessible." This refers to the preservation of data from the geostationary and polar satellites.

How specifically is that going to happen? Can you share with us how we are going to get these data out and what you are going to do in order to preserve the long-term integrity and quality of them? Because I think that this issue is most important in the context of Senator Gore's question and of our significant concern about the current gathering of data, and it is important to a number of tremendously important policy issues that are confronting us.

Dr. KNAUSS. Senator, one of the things that has happened in the last 8 years is that NOAA's budget has been badly beaten down. This last year's budget request from the President is a considerable improvement over what we have had for some time.

One of the ways in which NOAA has saved funds and tried to live within its program and do all the things that all our pieces of legislation say we have to do and should do is we did starve our data management, data archiving program. I am trying to force-feed it a bit by putting more funds into it and reorganizing it a bit and getting on with what I think is a very high priority. I could go into considerable detail, but that is the essence of it.

Senator KERRY. You are being very nice. I think the last few years have been a disaster, and I think that your statement underscores in a nice way, perhaps much nicer than it deserves, the disastrous impact these inadequate budgets have had on the future of this country. They have threatened our decisionmaking and knowledge-gathering capabilities which are critical to understanding the very, very important issues that we face.

And it is just one more example of how we could be penny-wise and pound-foolish by depriving ourselves of an "infrastructure investment," which in the long term strips us of our ability to lead the world in technologies that are just vital to us.

You say NOAA's budget has been sort of worn down or whatever, which is a very polite word for what I think has been the near-rape of an agency and the creation of an enormous disability which we now face.

Dr. KNAUSS. Well, I think to put it in a different light, the NOAA satellites which are primarily used for sort of real-time weather forecasting and this kind of thing, that part of the operation went very well and has gone very well. However, that data, as you point out, can be used for researchers, can be used for other purposes, and it is that part of the savings of that material and making it available over the long term, that is the part that essentially got cut back, and that is the part that we are trying to do something about.

Senator KERRY. Well, I am talking about, beyond that, the ability to conduct some of the analyses necessary with respect to global climate change, cloud cover impacts on the atmosphere's, temperature, and other activities. We are really just scrambling to meet all these important research needs.

Dr. KNAUSS. That is what I meant by having that data available for other purposes.

Senator KERRY. Let me turn to Senator Gore.

Senator GORE. Thank you very much, Mr. Chairman. I am just going to follow right along on that line of questioning.

I have conducted a series of round table discussions, Dr. Knauss, on the global change program, and a number of the leading scientists around our country have been kind enough to come in and spend hours upon hours going over exactly what information we need to address the most crucial questions we need to answer in order to better understand global change and come up with solutions for the unprecedented problems that we face.

In making an inventory of those questions and then making an inventory of the information currently available, one finds rather

quickly that we have collected enormous amounts of data which could, if they were accessible, properly processed and understood, give us the answers to a great many of the most important questions still pending resolution. You understand what I am saying.

You agree with that statement, do you not?

Dr. KNAUSS. I agree certainly in most of what you say, yes, sir.

Senator GORE. All right. We will get to whatever you disagree with in a minute.

A lot of the information comes from satellites, and let me just focus on Landsat for a minute. One of the most crucial questions is what has happened to land use on the surface of the Earth over the last 20 years, area by area. That is one of 25 or 30 crucial questions that need to be answered.

We have taken a complete photograph of the Earth's surface with Landsat every 2 or 3 weeks for the last 18 years, is that roughly correct?

Dr. KNAUSS. I think that is about right, yes, sir.

Senator GORE. Ninety-five percent of those pictures have never fired a single neuron in a single human brain, correct?

Dr. KNAUSS. I think that is correct, yes, sir.

Senator GORE. I have asked the scientists: Well, why do you not look at the Landsat data. You know what they say, do you not?

Dr. KNAUSS. Too expensive.

Senator GORE. They say: It is a joke; the Landsat program is a total joke where data management is concerned. The scientific community cannot have access to those images. The taxpayers pay to put the satellites up and take the images and store the data, but we cannot give those images to the scientific community.

Why do we not give them to the scientific community? Why do we not set up a program that would make them useful to people, instead of just storing them in storage bins and not letting anyone look at them? Can we change that policy?

Dr. KNAUSS. Under the Commercialization Act, as you well know, that data is proprietary data which the company that has the data can sell and does sell. The government can buy that data. The government can and does buy some of that data for its scientists.

I think the issue is not do they buy any of it. They buy some of it. Do they buy enough of it? I think most scientists would say no.

Senator GORE. Do you know who the biggest user of those data is?

Dr. KNAUSS. I think it is the Department of Defense.

Senator GORE. Do you know who the next biggest user is after DOD?

Dr. KNAUSS. No, sir.

Senator GORE. I am told it is the McDonald's Corporation. Now, maybe that is another of many apocryphal stories that somehow get linked with the McDonald's Corporation, but I am told that that is the case, that they and some other nationwide retail chains use images to look at traffic patterns and urban concentrations to assist in locating new retail establishments.

Is that correct, Mr. Pyke, do you know?

Mr. PYKE. That is certainly a reasonable application, and that is one of the legitimate commercial uses of Landsat data, yes, sir.

Senator GORE. OK. Now, outside of locating new fast food hamburger outlets, are there any other uses you can think of that we can use these data for?

Of course there are. The world is experiencing the worst environmental crisis in the history of humankind's existence on this planet. A lot of the information we need to solve the problem is stored in your silos of data.

But the current policy does not allow us to look at these data. I mean, it is really stupid, that policy is really stupid. It is similar in some ways to our agricultural policy of a few years ago, where we would store these massive quantities of grain until they rot, while millions of people starved to death.

Well, we have these massive silos of data rotting while we have massive ignorance of exactly how to solve the problems that we face with the environment, and I for one am hungry to see us gain access to those data.

What can we do to make it possible for scientists to see these data, Dr. Knauss? And I know you personally are frustrated by this Commercialization Act. I mean, you know this a lot better than I do and I am sure you have been tearing your hair out about it. But the scientists and others who want the information tell us that it is just impossible to get.

If we took the bit in our teeth here in this committee to propose changes in the program which would make your information accessible to scientists who are studying global change, how would you recommend we go about it?

Dr. KNAUSS. Well, let me make one thing very clear. At this point anyway, the Landsat data is not Department of Commerce data. It is not NOAA data. I am responsible for the rest of the satellite data, the satellite data that comes from the NOAA satellites, but not for the Landsat data.

The Landsat data is a commercialized program and there is a commercial company that is responsible for that. So we would have to change the act or provide sufficient funds within the government to provide for the scientists to buy the data from the company.

Senator GORE. Well, but the pricing policy is ridiculous, is it not?

Dr. KNAUSS. Sir, you are probably correct. But one must recognize that it was both Congress and the Administration that developed the Commercialization Act.

Senator GORE. You mean that Congress participated in this mistake?

I find that almost impossible to believe.

Dr. KNAUSS. It was before my time, but that is what I have been told, sir.

Senator GORE. Well, regardless of where the error first originated—and I had always believed that this was a commercialization initiative coming out of the Reagan Administration, but the record will reflect whether that perception is accurate or not—I would like your assistance, either publicly or privately, to design changes to the Act to make it possible to get either a sensible pricing structure or a complete change in the Act to make this information accessible.

It really is a nonsensical policy the way it stands today. Could you help me with that?

Dr. KNAUSS. I can try. But maybe Mr. Pyke who knows more about this subject than I do, can say a few words.

Senator GORE. All right.

Mr. PYKE. Senator, we are in a bind with regard to making these data available to the global change community and others on a broader basis, and certainly with a different price structure than we have now. Following the premises of commercialization, which were accepted by both the Administration at that time and the Congress, the contract that was entered into with EOSAT did make the data, all of the Landsat data beginning with that that was acquired in the early days, 1972 on, available to EOSAT and gave them the rights to market and distribute that data until 1994 or on a sliding basis after that, a 10-year sliding basis after that, from the time in which that data was acquired.

At this time that contract is in force. And the contract also permits EOSAT to charge whatever the market will bear, if you like, to charge whatever it feels is a reasonable price, without the government saying what it should charge for the sale of that data.

There is, however, a provision of the Landsat Act through an amendment a few years ago that makes it possible for EOSAT to make a good deal of this data available for research purposes to government agencies and other individuals or organizations, and it is possible that under that provision, with the right arrangements, alternative arrangements might be made to provide data for research purposes both by government agencies and, through the sponsorship of government agencies, by others.

Senator GORE. Well, I would like to actively pursue that. And we cannot solve this problem in dialogue during these few minutes, but I would like to have another meeting with you all at your convenience to go over those potential changes.

Now, on page 7 of your statement, Dr. Knauss, you say in the middle of the page: "The Administration has committed to continued operation as long as Landsats 4 and 5 function." Does that mean that I am mistaken in concluding there is no money in the budget for that purpose? I do not quite understand what your statement means.

I looked at the budget request and it seemed to me—and I may be reading the budget request incorrectly—that you requested zero dollars and zero cents for continued operation of Landsats 4 and 5 in fiscal year 1991. And yet you say here: "The Administration has committed to continued operation as long as Landsats 4 and 5 function."

Can you help me understand the conflict here?

Dr. KNAUSS. I can try. First, Landsats 4 and 5 are way beyond their life expectancy, so when these budgets are put together, we assume that they are not going to be operating in 1991. There need not be any money in the budget because we feel they will be dead, point one. Point two, NOAA itself is not paying for the use of Landsat, so it is not in our budget. How Landsat is being paid for is by contributions from those agencies within the Federal Government that make use of the Landsat data. So the Administration position is that, yes, if Landsat is still operating in 1991, we will con-

tinue to pay for the operation of Landsat, and the agencies that make the most use of that Landsat data will be taxed for the payment of that.

Senator GORE. That is another budget gimmick, then. No money is put in the budget because of the assumption that they will fail, but really we are sort of hoping and assuming that they will continue even longer past their design lives, and when that occurs then the money will be added; is that right?

Dr. KNAUSS. It will come out of the budget. That, by the way, sir, has been the way it has been operating for the last two years.

Senator GORE. Now, you said no NOAA money goes into operations. In fiscal year 1990 NOAA contributed $9.5 million and other agencies contributed $9.5 million.

Dr. KNAUSS. I am sorry, you are correct on that.

Senator GORE. But there is no money in your request for fiscal year 1991, correct?

Mr. PYKE. For fiscal year 1990, Senator, the President made an amended budget request and asked the Congress to provide funds for operating Landsats 4 and 5 for all of fiscal year 1990, and Congress only appropriated enough funds for half a year's operation, the $9.5 million that you just referenced.

Senator GORE. Right.

Mr. PYKE. And as a result, we were able to obtain funds from those Federal agencies who have been making primary use of Landsat data. So we have a history of success in depending on those agencies that have a need for the data to help out, to come through and legitimately to help defray the continuing costs of operating these satellites so long as they continue to be operable.

Senator GORE. Well, I am going to wrap up my questions here with just a couple more brief ones.

You have acknowledged here that the commercialization program has been a failure. You have acknowledged that the program is valuable, but there is no money in the budget for it's long-term continuation.

What is the alternative to commercialization? Are we going to just sit here and watch this program die when we have had a successful data collection effort giving us information about global change? And now, just at the time when world policymakers are focusing on this information and how to respond to it, we let it die?

That is where this policy is headed. That would be a nonsensical result, but that is where it is headed in the absence of some leadership from the Administration, some proposal to take the place of the failed commercialization program.

Do you agree with that?

Dr. KNAUSS. The Space Council is addressing this issue—and I expect there will be an Administration decision on this issue shortly.

Senator GORE. Well, I guess that is the best we can do this morning. And I sympathize with your position, Dr. Knauss, and the position of your colleagues. I have watched you operate for a few years now and I know that you are professionals and that you are sometimes frustrated that both Congress and the OMB will not recognize the value of these programs, and I consider myself an ally of that particular point of view.

But let me say through you to the Administration, insofar as one can speak in hearings like this one, that this policy is really a terrible lapse in judgment on the part of the Administration. Now, this program is a special project of Vice President Quayle and he has had some successes at the Space Council.

I would urge the entire Administration, and especially the President and the Vice President, to give personal attention to this program. These are the eyes and ears of the United States on global change, and if we let these instruments die then our capacity to respond to the overriding issue of our age will be greatly diminished.

It has been given to the Space Council. The Space Council has got to produce. It has been like the Perils of Pauline for too long now. I personally think that the continued commitment to this ideological view that commercialization is going to solve all these problems has been holding up development an imaginative, bold response.

But I think that, now that you have abandoned that policy in your statement, the Administration needs to come forward with an alternative suggestion.

Mr. Chairman, that is all I have right now. I appreciate the time. Thank you.

Senator KERRY. Thank you very much, Senator Gore.

Senator Stevens.

Senator STEVENS. Thank you, Mr. Chairman. I have a bill on the floor, so I will be very short.

I wanted to ask whether the funds that are requested in this budget are sufficient to implement the monitoring system that we mandated take place with regard to the driftnet vessels in the north Pacific? We now have an agreement, I understand, with all of the nations that are using driftnets, with the exception of Korea, North Korea. We will have to deal with those in another way, I assume.

But is this money sufficient to maintain the program that was tested this last year, to actually track these vessels that now have the transmitters on them when they are operating driftnets?

Dr. KNAUSS. Yes, sir. As I understand it, we have transmitters on about 800 of these fishing vessels at present, and it is a standard program. And it is my understanding that it is not that expensive a program, once you have the transmitters, to keep the program operating, and it will be operated, sir.

Senator STEVENS. And is it a program developed now so that there is actually going to be real time data provided to the Coast Guard and to others that are monitoring this system, so we can get some warning when these vessels go outside of the bounds of the areas that they are permitted to be in?

Dr. KNAUSS. Well, if it is not realtime, it can be realtime. I think we have no reason to believe it is not almost realtime.

Senator STEVENS. That is good. That is good news.

On the geostationary weather satellite, can you tell us whether you have a contingency plan in the event the current satellite, number 7 I believe it is, that we are relying on does fail before a replacement is launched?

Dr. KNAUSS. Yes, Senator. We are working on a contingency plan. We have tested a number of the components of the contingency plan. We expect to have a full-scale test of that plan either in late summer or early fall, as soon as all the components of it essentially have been tested.

Senator STEVENS. As I understand it, we are relying exclusively on satellite number 7 for the weather information that is used by commercial television and others, and by yourselves. It is that sole remaining satellite that we are relying on, is that right?

Dr. KNAUSS. It is the sole remaining geostationary satellite that we are relying on. We have these two polar orbiters which also provide us information, and it is those polar orbiters which we will be using as a backup contingency plan, if you will, for providing comparable kinds or analogous kinds of information if we ever lose the GOES.

Senator STEVENS. You have $109 million in the budget for this system now. My staff informs me that the cost estimates for the replacement have now risen to exceed $900 million from an original estimate of $500 million.

Can you give us any kind of an indication of whether there's any change in the time frame for the availability of this replacement system?

Dr. KNAUSS. At present we are assuming that the satellite, the next geostationary satellite, will be launched in mid-year 1991. We have a full-scale review, NASA and NOAA, that will take place next month, in July. At this point we have no reason to believe that there will be any further delay, but there might be. If there is, we will know at this review in July, and if there is a delay you will be informed.

Senator STEVENS. Well, I do not imagine we will be working up the appropriations bill at least before July, and I hope that you will notify us if there is any problem with regard to that.

It is my understanding that the polar orbiting satellites have also lived beyond their life expectancy. We now have one, polar orbiting satellite "D" by the information I have, that is scheduled for launch this year. Is that still on time?

Dr. KNAUSS. Yes and no. Our polar orbiting satellite program has been going very well and we have the satellites ready to be launched as needed. The satellites themselves have proven to be much longer-lived than the original design plan for them, and it has been a very happy operation up until about 3 weeks ago, when we found that—or I should say, NASA found that there was a possibility of an accident on the launch platform during the period of launch with respect to a valve. It is a remote possibility, but a real possibility in their minds, which would endanger launchpad personnel in the area.

That is now being looked at in some detail, and it may require some redesign of that system. The worst possible scenario is we could be a year, as I understand it, before that redesign is done, which would mean that we would therefore have to delay the launch of that next polar orbiting satellite for a year.

That's the worst-case scenario. It may be, after further looking at that matter, that they will decide that the issue is not all that critical and that we will be back on schedule.

Senator STEVENS. Are these shuttle-launched?

Dr. KNAUSS. Pardon?

Senator STEVENS. Are these shuttle-launched?

Dr. KNAUSS. No, sir.

Mr. PYKE. These are launched on Atlas vehicles. They are launched for us by the Air Force out of Vandenberg Air Force Base in California.

Senator STEVENS. But there is no indication that the existing satellites that have lived beyond their life expectancy are failing. Is that right?

Dr. KNAUSS. No, sir, they are living longer than their original design. In fact, as I understand it, the next step is to increase their design life from two years to three years, and that's a project we have underway.

Senator STEVENS. I have some additional questions, Mr. Chairman, but I get a second shot at Appropriations. I will ask them there, so I can get back to the floor.

Thank you very much.

Senator KERRY. Thank you very much, Senator Stevens.

Senator Gore, do you have any more questions before we move on?

Senator GORE. Just briefly. On the question of resolution in Landsat, what is the status of your current limitations on resolution, how many meters?

Mr. PYKE. Well, the currently operating Landsat has 30 meter resolution and Landsat 6, which is scheduled for a December 1991 launch, will have 15 meter resolution.

Senator GORE. Could it go tighter than that?

Mr. PYKE. No, sir. My understanding is that is the design of the enhanced thematic mapper, the actual instrument being designed for Landsat 6.

Senator GORE. At one point you had a statutory, or a legal constraint, did you not?

Mr. PYKE. I am not familiar with that. I am not sure that there are any limits at this point in time.

Senator GORE. I believe that you previously had one.

Mr. PYKE. The design of the 15 meter capability is a design chosen by EOSAT to satisfy the market as they saw it.

Dr. KNAUSS. I am told, sir, that we have no policy constraints.

Senator GORE. What is SPOT's resolution?

Dr. KNAUSS. SPOT is wider.

Mr. PYKE. SPOT has a ten meter resolution, sir.

Senator GORE. Ten meter resolution.

All right, just one final set of brief questions. The issue of commercialization is not the only issue in the Landsat data management area. There is also the whole question of what kind of software algorithms and other data processing means exist to pull out specialized data streams.

I am told that these data processing capabilities do not exist. Let me give you just an example, a hypothetical situation to illustrate the question I am trying to ask. Let us say as part of the global change program a group of vulcanologists wanted to scan through the entire data file to pull out the images of active volcanoes during the month of December 1989.

The computer capacity to scan the data, and pull out images that conform to a designated set of patterns, exists. But there is no framework, or no structure, within the Landsat program or the EOSAT data management process now to do that.

There are literally thousands of similar queries which could, with the assistance of massively parallel supercomputers, provide a fantastic improvement to the ability of global change scientists to understand what they are looking for. Is NOAA completely out of that game now?

Is there any way that you can help us answer questions like that?

Dr. KNAUSS. Certainly you put your finger on a very important point. If the data is expensive, people do not spend their time doing the kinds of things you suggested, developing the algorithms and so forth.

Senator GORE. Right.

Dr. KNAUSS. We do do this, by the way, with our polar orbiting satellites. In fact, we find volcanoes this way. A couple of people up in the Upper Peninsula of Michigan, scientists, have algorithms they developed for looking at volcanoes. You are right. Because the data is expensive, there is not as much effort being put into what one might call value-added programs, and it is one of the reasons why I suspect commercialization has not gone as well, because it is sort of a chicken and egg pheuomeion.

Senator GORE. Right. Well, what are we going to do about it?

Dr. KNAUSS. As I said, we in NOAA, and I think we in the Administration, are convinced that commercialization has not worked.

Senator GORE. Yes.

Dr. KNAUSS. That is about as far as——

Senator GORE. You said "we in the Administration, I think."

Dr. KNAUSS. Well, we in the Department of Commerce has decided that commercialization has not worked.

Senator GORE. Was that testimony cleared by OMB?

Dr. KNAUSS. Yes, sir.

Senator GORE. So OMB did not censor that particular part of your statement.

Dr. KNAUSS. I think what I am saying is——

Senator GORE. It denied cert. It did not necessarily render an opinion.

Dr. KNAUSS. The Department of Commerce view of this issue is that commercialization will not be practical, at least for a decade and perhaps for at least two decades.

Senator GORE. Ironically, I think commercialization could succeed on many levels if we would stop pursuing it in this rigidly ideological, silly framework that is imposed on the program now.

But let me just say that, here we have this Mission to Planet Earth program, which I strongly support, designed to collect huge new quantities of data over the next 17 years, when much of the data we need to answer the questions we are pursuing already have been collected. They are just sitting there rotting because the officials in the bureaucracy cannot figure out how to allow the scientists to look at the data.

It is really one of the most ridiculous situations I have ever encountered. And I do not know where the proposal for a solution can

come from if it does not come from NOAA. You did not create the problem. The ideologists in the Administration created the problem. But the proposal to solve the problem has to come from NOAA, I think.

Am I wrong about that? Is that unfair to you?

Dr. KNAUSS. Senator, let me make several points, one of which is that there is a lot of satellite data. Landsat is only one.

Senator GORE. Right.

Dr. KNAUSS. The rest of the satellite data is freely available. We are doing our best to make it available. It is being used to look at problems of climate and global change.

The Landsat data, as you pointed out, because of the commercialization is a separate issue. One of the CES committees, the working group on global change, has taken on the task, partly because I have asked them, to review what role Landsat data does play in their long-range plans for looking at the issue you are so concerned about, climate and global change. I expect we will be hearing from them some time shortly, and perhaps on the basis of what we hear there will be some decisions made about the future.

The point to be made is that the Landsat 4 and 5 and the continuation of Landsat 6 will get us to the point where the EOS program goes up, and the sensors there will be comparable to what we now have on Landsat. So that there will be indeed a continuation of that kind of information even if there is nothing beyond Landsat 6.

Senator GORE. A continuation of land remote-sensing until Landsat 6 dies?

Dr. KNAUSS. I mean, by the time Landsat 6 dies NASA's new Mission to Planet Earth program will be flying around the Earth and that will carry sensors on it comparable to what we now have on Landsat.

Senator GORE. Well, thank you very much for your responses. You said soon this proposal will come. What does "soon" mean? Within the month, within a matter of weeks?

Dr. KNAUSS. Which proposal, sir?

Senator GORE. Pardon me?

Dr. KNAUSS. Which proposal?

Senator GORE. Well, you said you expected the executive branch to complete its review and have a new package of proposals on what to do about this. When do you think that will happen?

Dr. KNAUSS. I would not care to judge, sir.

Senator GORE. This year?

Dr. KNAUSS. I would hope so.

Senator GORE. OK, all right. Thank you very much.

Thank you, Mr. Chairman.

Senator KERRY. Dr. Knauss, let me just follow up on that. When you say you would hope so and you would not want to judge on when we will have a proposal, that kind of leaves us hanging here.

Dr. KNAUSS. I recognize that.

Senator KERRY. Are you comfortable with that? I am not.

Senator GORE. Yes, this policy is past its design life.

Dr. KNAUSS. It is my understanding that this matter is going to be brought up before the space council some time relatively soon. I

am not in a position to judge what action or in what time frame the Space Council will act.

Senator KERRY. Is this policy matter dependent on the Space Council's actions?

Dr. KNAUSS. At least in part.

Senator KERRY. Why is that?

Dr. KNAUSS. Because that is where these decisions are made.

Senator KERRY. Well, which decision are you referring to specifically?

Dr. KNAUSS. A change in policy with respect to Landsat.

Senator KERRY. What about beyond the Landsat piece? What about the larger issue of the information gathering and dissemination? I mean, it seems to me a broad set of issues were touched on both by myself and Senator Gore.

Dr. KNAUSS. I think with respect to everything but Landsat, with respect to those satellite programs for which NOAA has primary responsibility, I believe I can address those issues. I have tried to address those issues both in my testimony and in answer to your questions. The Landsat issue is one that is in some sense beyond my responsibility.

Senator KERRY. Let me just call to your attention to an earlier report—you remember this [indicating]?

Dr. KNAUSS. Yes, I do.

Senator KERRY. This is the "Rededication of NOAA Vision," from January of last year. So here we are now, a year and a half later, almost to the day a year and a half later after this document was published..

"The vision, a rededication of NOAA. If NOAA fulfills this role, it will be in a unique position to sustain the long-term resolve and the emerging national program for documenting, understanding, predicting, and providing information on global change in the natural environment."

And it includes a very ambitious, and I think appropriate, discussion of the challenge, and NOAA's role in providing an Earth systems response, particularly in the areas of developing models documenting and understanding the change. And it closes out with the following statement:

> We are today in a position unprecedented in human experience. The environment in which we live will change dramatically in the span of our own lifetime through global changes that are in part of our own making. These changes are occurring faster than we are understanding them. How well we respond nationally and individually to a rapidly changing Earth will depend on an understanding of these trends, of their causes, and their impacts on the future habitability of the planet. It is in the national interest to act to learn all we can as quickly as we can and as efficiently as we can to meet the future responsibility. A revitalized NOAA is an essential element in any national plan to do this.

I would hope, Dr. Knauss, that as we deal with this issue in the context of NOAA's reauthorization over the next few days, that you will go back and address this issue with those involved in a way that will come up with a stronger response. I mean, I think Senator Gore's assessment of the stupidity of this blockade on information, given the mandate that you set up for yourself a year and a half ago——

Dr. KNAUSS. Senator, we are indeed doing almost all of the things that are in that report. We are working very hard and we are doing an excellent job.

We are not doing a good job with respect to Landsat. Landsat is somewhat beyond my control. But it is a small part of the total effort we have in NOAA under climate and global change.

Senator KERRY. Well, let me ask you this. Should you be asking, and should we be trying to authorize money, for the purchase of that information, or should we be changing the law with respect to the provision of those data outside of commercialization's current restraints? Have you asked us to do either of those things?

Dr. KNAUSS. With respect to changing the law with respect to the commercialization, that is really not a NOAA issue. With respect to the data from Landsat with respect to climate and global change issues, which I am responsible for and I am concerned about, that is where we have asked the CES committee to address the issue as to whether or not, how important that data is. Senator Gore thinks it is extremely important.

Senator KERRY. Do you agree?

Dr. KNAUSS. How important? That data is important. As to where I would put it on a priority list of all the other kinds of data we need in the CES climate-global change issue, I am prepared to let a committee of CES come and make that set of recommendations.

I do know that among the various Federal agencies that are looking at various aspects of climate and global change, that data is more of value to some of the other agencies in the Federal Government than they are to the NOAA scientists. So I think it really will be with respect to some of the other agencies, the Department of Agriculture, the Department of the Interior and others, who are also involved in this climate and global change issue.

I am not saying there is no interest in NOAA, but we are not the primary users of that data.

Senator GORE. Will the chairman yield on that point?

This has come down to a kind of budget hot potato game, where all the users were asked to say how critical and essential are these data to your task. Translated through budget-ese, what that question really meant was which one of you will take the hit in your budgets.

And the only agency that was willing to say it was essential turned out to be the Department of Defense. So now we look at the prospect of militarizing the Landsat program because nobody else is willing to fund it, even though they do believe the information is important. They are not willing to say, we want it in our budget, because it would require cutting out so many other core missions.

Mr. Chairman, the space subcommittee has chartered a hearing on the general issue of data management and I think it might be good for us to hold that hearing in concert with each other. Of course, it will be up to Chairman Hollings. But I wish to pursue the larger question of data management policy.

I agree with your statement, Dr. Knauss, that Landsat is unique. But while it is the single worst example, it is not the only example of extremely valuable data sets going mostly unused. There are lots of such data sets.

In fact, the list of the data sets themselves is just incredible. I have been involved in compiling such a list and it really is amazing how much data we have that are not being used.

I would also recommend, Mr. Chairman, that we ask our two staffs to follow up with Mr. Pyke on a suggestion that he made about a tiny provision in the current law which allows EOSAT to make information available to research scientists under some different conditions, which I think could be interpreted to allow a change in current policy under the existing statute with an imaginative application of that provision.

So I hope we can look into that and maybe solve it quicker than anticipated.

And in conclusion again, let me just say to Vice President Quayle particularly: This is a chance for you, Vice President Quayle, to do a good job on something for which you have been handed responsibility. It is a mess right now, it is a real mess, and we are waiting for a proposal. We stand ready to work with you to try to solve the problem, but we want a proposal.

Thank you.

Senator KERRY. Thank you very much.

Dr. Knauss, let me just emphasize at the end of this discussion that, as you know, I have been one of the strongest supporters of NOAA and one of the strongest advocates of increasing its role and of wanting it to tackle these issues. I just think that, beyond you, there are some built-in restraints to the system which are becoming very frustrating, and I think it is extremely important to accelerate the process of change in our data gathering and analysis practices, rather than accede to some of those restraints. That is why I am emphasizing that point.

Just a last quick question. On the NOAA D launch pad problem that you pointed out, it is my understanding that the Air Force which uses a similar spacecraft design, does not hold that problem as a particularly serious restraint to proceeding with their launch plans. Can you give me a sense of where you stand in your personal assessment of this problem?

Mr. PYKE. Mr. Chairman, we have heard that the Air Force, which has comparable underlying spacecraft structures within some of its spacecraft, is planning to go ahead and launch despite the fact that they have a similar problem. We have pointed this out to NASA and NASA is currently revisiting the decision that we should hold up on this launch, taking into account all currently available information to see whether, based on the NASA criteria, it may be possible to proceed.

Senator KERRY. So we are really applying two different criteria to the NOAA and DOD launches. Air Force launches will not be slowed up, is that not accurate?

Mr. PYKE. We have heard that the Air Force intends to continue launching spacecraft with a similar design.

Senator KERRY. Let me leave the record open in the event that there may be other questions anyone wants to submit in writing.

And I thank you all very, very much for your time and for your patience and your effort. Thank you.

We will proceed to the second panel, which was really the first panel: Joe Witte, Dr. Baker, and Mr. Eric Rodenburg.

Is this all of NOAA leaving now? Is anybody working today? [Pause.]

Senator KERRY. Gentlemen, thank you very much. We are delighted to have you here today, each and every one of you.

Joe Witte is the Chief Meteorologist for NBC News. Dr. Baker has been here previously. He is President of the Joint Oceanographic Institutions. And Mr. Eric Rodenburg is Research Director for the World Resources Institute and has just issued a most interesting report.

Mr. Witte, why do you not lead off, and Dr. Baker and then Mr. Rodenburg. Thank you.

STATEMENT OF JOE WITTE, CHIEF METEOROLOGIST, NBC NEWS

Mr. WITTE. Mr. Chairman, thank you very much.

The question is how important are satellites? I say extremely important. And I might also mention, we should say congratulations to Ford Aerospace and McDonnell Douglas also for having a successful launch of an INSAT satellite. Earlier this morning it went up. This is a replacement satellite for an Indian Ocean bird, and not only will it be a communications satellite, but it will indeed be a weather satellite. And this is extremely important because India just suffered a few weeks ago one of its worst typhoons in a decade.

So be that as it may, how important are satellites? Very important. There is an old Chinese proverb: A picture is worth 10,000 words. And that certainly applies in my case as a forecaster.

I use the National Weather Service models to make the forecasts that go across the country, but to help verify these forecasts and to lean toward one model or revise toward another model we use the satellite time lapse and stills to take a look-see, see what is going on. Are the models mathematically really doing their job, or should they be sped up, slowed down?

Images that I use are used on network television. And let me shorten the section coming up. Basically, a lot of people watch TV. In the mornings we have about 10 percent of the country tuned in on any one morning watching television. In the evening we have one out of three homes across the country. That is roughly 33 million TV sets.

Basically, a lot of taxpayers and I think a lot of people who would support a satellite program, who would support expanded moneys toward satellite programs, are watching and understanding.

It is important that a lot of people watch because there are some critical matters, of course, that need to be passed off. And the importance of weather I think is shown in this little segment here. If you look at local weather forecasts, a lot of them are placed at the end of the news segment, of the news program, and that is because the news people want you to watch the entire program, see all the commercials, and then get to what you want to see most of all, and that is the weather forecast for your weekend.

Newspapers do the same thing by putting the sports page at the end of the paper in the back.

So weather is important. Advertisers realize it. Another example of how important TV weather is is the fact that "Nightline," the

ABC program, has just finished 10 years of very excellent news programming, and the fifth most watched program was the program they did the night that Gloria was moving up the east coast in September 1985.

Just for your information, Tammy Bakker and Jim Bakker was the No. 1 program. It is hard to compete against that.

Senator GORE. They were moving up the east coast, too.

Mr. WITTE. Yes, they were, in a different way.

So satellite images helped millions of people see what was going on with Gloria, millions of people in Washington, New York, Philadelphia, Boston.

And of course, just recently we had last year Hurricane Hugo sweep upshore along Charleston, SC, in fact hit Charleston, SC. Twenty-nine people were killed, a terrible tragedy. But a lot more would have been killed without satellites.

It is estimated that 350,000 people were evacuated. And this is very important. Folks took the warnings issued by the local officials very seriously because they themselves could see as individuals the danger that Hugo presented, how big it was, how powerful it was.

We might recall back in 1900 6,000 people in Galveston, TX, lost their lives to a hurricane, long before satellites of course. So one question is could a tragedy like Galveston happen again? It could perhaps. One study indicates that to evacuate New Orleans itself, which is below sea level, could take two to three full days to move the people out of the way for a Hugo-sized storm.

It is important that people are able to see something, in a sense, because if they cannot see, feel or touch something it is easy for the average person to have apathy. He will say: Ah, it will not happen to me; I will not have a car accident, I am a careful driver; the hurricane will not hit me; why should I pack up my family, waste time, money, drive inland to some motel, and really miss seeing what a hurricane is about?

There is a psychology involved. You have got to really convince the people that, yes, this hurricane may hit in your area, it is a good insurance policy perhaps to evacuate.

Not only do you have to do that convincing, but you have got to do it fairly quickly when it comes to television. People watching television are used to seeing and being sold with 30-second commercials, and that is one of the wonderful things about satellite time lapse images, that they last about 10 to 15 seconds. It is pretty easy for the average person to see something big is on the east coast, west coast, Gulf of Mexico; maybe I should pay attention to what they say after this.

And it might be noted here that the forecast just issued by a forecaster in Colorado, Dr. William Gray, says that this summer-fall hurricane season could be a big one, perhaps three major hurricanes. And he sees the decade of the eighties returning to a decade of the forties and fifties and sixties with respect to hurricanes. We had a lot of strong ones in those earlier decades.

It has been relatively quiet since the sixties, and he says we ought to watch out.

Now, in this particular case I have used the hurricane as an example of how serious the weather can be, how it is important that

people understand the dangers. The same thing could be said of tornadoes in the Great Plains, winter blizzards on the Great Lakes, nor-easters that can bring Washington, New York, and Boston to a standstill with 1 to 2 feet of snow, or Pacific storms that can sweep onto the west coast. The Columbus Day storm that hit Washington in 1961 is an example.

So satellite images can save lives, and I think the taxpayers know that. I think they see the value of that, and I think they are willing to support it.

Now let me change topics shortly here to a new one and an important one. That is education. It has been estimated that only six percent of the American public have really a reasonable, reasonable understanding of scientific issues. We have heard many reports recently that students, grade school, high school, are lagging behind in science awareness, lagging way behind many other countries.

We need future scientists in our country. Perhaps you saw the New York Times article last week decrying the low number of minority Ph.D.'s in the sciences that we have, astoundingly low, just a few hundred.

How can we as parents, teachers and leaders spark an interest in the sciences? Weather satellites, whether you see them simply daily on the weather report or whether you see them as a part of a more evolved report on greenhouse warming, all can play a role.

And it really can be a hands-on experience for some schools and many students. Many schools have put together their own satellite receiving stations with very little money, under a few thousand dollars—bake sales, car washes to raise some funds to get the equipment to put together. And they can go in their science room early in the morning and after class, before class, and actually see real time images coming into their room—something they have done, something they have put together, and it is a truly exciting thing to see.

There is an excitement of science there. And they can see a number of other things also. They can see, because of satellites, the El Nino coloring in the Pacific Ocean. One of our biggest concerns of greenhouse warming is what is happening between the atmosphere and the ocean, what is the feedback mechanism going back and forth? There is a lot of questions there. The El Nino gives a sample of some of the complexities involved.

We had an example a few years ago about the ozone hole over the Antarctic. How many people really believed it because of satellite images that we had? I think a lot of people. So there is a public awareness, a public education, that comes not only with students but also a public awareness that comes to the common community, our citizens.

As you Senators have noted, we have a tremendous challenge ahead of us, and that is the challenge of trying to understand global change. How much can we pollute the atmosphere and the oceans and still maintain life as we know it?

We live in what has been called by others a Goldilocks situation. We live on the Earth as opposed to Mars, which is too cold, Venus which is too hot, primarily because of the greenhouse effect of the atmosphere. Ours is just right. It may not always be that way.

The IPCC, the Intergovernment Panel on Climate Change of the UN, has just come out saying perhaps the CO_2 will double in 35 to 60 years. There are a lot of questions still we do not know; we do not know the exact answers.

We just went through the warmest March on record, according to Jim Hanson's worldwide data. So the cherry blossoms that you saw here in Washington blooming much earlier than normal were perhaps not due to greenhouse warming, but was a reminder to us of what might happen in a small scale.

There are a lot of questions we do not know. Huntsville, AL, scientists say that, looking at satellite data, they do not really see any warming in the eighties, but this is just the eighties they are talking about. They are not going back very far in history. They need more data.

Just last Friday—and we have a fellow from the World Resources Institute here—we had on the Today program an expert on deforestation of Brazil, a Dr. Hammonds. He talked for about 5 minutes in a conversation, but in one satellite photograph image he made millions of viewers across the country aware of the tremendous number of forest fires that had taken place over a month's time in Brazil. You could see the specks of light on the satellite photograph. It was very surprising. The numbers are in the thousands.

It has been estimated that there is essentially a tropical forest the size of Tennessee disappearing every year, and I think the new estimates would perhaps increase that by 50 percent.

But deforestation of course is only one concern of the greenhouse warming theory. Air pollution, population growth, sea level rise, climate changes, the role of clouds and ocean together, the interaction, energy use of course—how are we going to use energy, solar energy.

What about agriculture? What is going to happen there? A recent report has just come out that perhaps the greenhouse warming will increase our production by about $10 billion or about 8 percent. But then they also said in the same report it may in fact decrease it by that same amount. But they also said there are a lot of considerations they did not put in their report.

All of which is to say the public needs, as well as scientists, a real understanding of this global change potential. Again, there are a lot of questions. We are finding out we need to ask some questions. There are a tremendous number of answers that we have no idea what they are.

The American public needs to be fed information so they understand that, yes, they may have to take measures with respect to driving their cars, it may certainly be worthwhile putting controls on their cars to keep down the greenhouse effect so that their children can live in a world that is really livable.

All of which is to say there are no easy answers to the greenhouse warming, but the public needs to be advised, up to date, kept up to date.

What can NOAA do as far as satellites? As far as I am concerned, number one as a forecaster, I need the information that comes via satellites to help improve the models. And secondly, I need the visuals that come from the satellites, and I need the vi-

suals that come from the NOAA Public Affairs Office, that really help me explain all the complexities, hopefully in a somewhat simple way, so they can comprehend that we just cannot say yes, we just cannot say no, and we all have to make compromises as a world community.

Thank you very much.

Senator KERRY. Thank you very much.

Dr. Baker.

STATEMENT OF DR. D. JAMES BAKER, PRESIDENT, JOINT OCEANOGRAPHIC INSTITUTIONS

Dr. BAKER. Thank you, Senator Kerry.

I would like to focus on global change issues. Over the past 30 years, NOAA's 31 polar orbiting and eleven geostationary satellites have collected information on clouds and winds, temperatures, rainfall, and snow cover, forests and vegetation, wetlands, ocean temperature and currents, and polar ice.

Most of that information is now being used internationally for global change studies. Long term continuity of this data is essential. NOAA satellite sensors have given us, with the current set of sensors starting in about 1978, a 12-year baseline of observations. This will extend to at least 20 years by the time of the new measurements proposed as part of NASA's Earth Observing System.

Thus, it is critical that these data be continued and calibrated and that the derived products be generated according to a scientific community consensus. To understand the greenhouse effect and global warming, we need to know how the coupled climate system works—it includes the atmosphere, ocean, land and biosphere—and how it is affected by increased concentration of greenhouse gases.

Satellite-borne instruments are directly relevant by helping us observe changing concentrations of gases, the effects of clouds, the interactions of the oceans and the oceanic and terrestrial ecosystems. We know that changing weather and climate are driven by energy from the Sun. NOAA geostationary satellites are now routinely monitoring the solar output.

We know that clouds reflect a large part of the incoming solar radiation. Changes in cloud amount by just a few percent could have the same effect as doubling carbon dioxide. Thus, accurate measurements of clouds are essential.

The International Satellite Cloud Climatology Program of the World Climate Research Program is collecting and studying information on clouds that are collected from the operational meteorological satellites.

Satellite measurements have also proved very valuable in monitoring the effects of volcanic eruptions on radiation. The Earth radiation budget experiment, ERBE, was designed to measure both radiation from the Sun and radiation from the Earth. These data are a key component of climate studies. The ERBE program combines observations from NASA's Earth radiation budget satellite and measurements from the NOAA operational satellites.

Unfortunately, these instruments are now failing. Aside from a French-Soviet mission for radiation measurements that is planned, called the SCARAB mission, there are no planned measurements of

radiation between the time those instruments fail and the time that the Earth Observing System starts late in this decade.

We also know that human-induced increases in trace gases, such as chlorofluorocarbons, have been implicated in the ozone hole. We know that if the ozone level in the stratosphere decreases, ultraviolet radiation at the surface increases, with deleterious effects. Ozone measurements are made routinely by instruments on the NOAA satellites.

The most important and variable determinants of the year to year changes in agricultural production are weather and climate anomalies. In order to predict weather and climate change, it is necessary to know the distribution of temperature and water vapor in the atmosphere.

Today operational weather satellites provide this data with both polar orbiting and geostationary satellites. The primary instruments are radiometers and sounders. A space environment monitor provides data on solar emissions. Non-remote sensing systems include data collection and search and rescue systems.

A second U.S. polar orbiting operational environmental satellite program, the Defense Meteorological Satellite Program, is operated for the Department of Defense by the U.S. Air Force. There are some important aspects of coordination that are needed here.

There are five geostationary satellites surrounding the Earth today, two operated by the United States., one by the European Space Agency, one by India, and one by Japan. As you know, only one of the U.S. satellites is now operating and its replacement is not scheduled until some time in 1991.

In the meantime, one working U.S. satellite is moved back and forth to provide the information we need. In fact, we have an agreement with the Japanese to try to get useful data from their meteorological satellites.

These satellites provide operational weather data, cloud cover, temperature, water vapor, real time storm monitoring, and sea surface temperature measurements. Sea surface temperature is particularly important for oceanography. The data have been used for tracking ocean currents and relating biological changes to temperature.

The Tropical Ocean Global Atmosphere program, which is attempting now to predict the El Nino, routinely uses the data from operational satellites for wind, cloud and temperature information.

The operational satellites have also been important in providing information about processes at the land surface. For example forest fires, urban heat islands, and volcanoes can all be routinely detected, as can snow and ice cover.

The details of deforestation can be monitored closely using a combination of the GOES satellites and the high spatial resolution information from the the U.S. Landsat and the French SPOT systems. The effects of acid rain and drought can be determined and is being determined in areas in both hemispheres.

This range of applications is broad, but it should be noted that the United States has not been willing to make a long-term commitment to the Landsat program. We need the Landsat data; the questions that were raised earlier are very relevant to this point.

There is a continuing broad-based need for operational satellites. They have demonstrated their usefulness and we must have the continuing information. The NOAA satellites are part of a global system whose success depends on their existence.

How can we ensure an adequate U.S. contribution to this global system? We need full funding of the operational satellite program and closer cooperation between U.S. agencies. The close cooperation between NOAA and the defense meteorological satellite program needs to be expanded to include both ocean and land measurements.

NOAA needs to make sure that it is fully interactive with the proposed Earth probes and Earth Observing System of NASA. The data system planning for the Earth Observing System data and information system must involve all relevant agencies. Today we find that the areas of atmospheric science are better coordinated than those of oceans or land processes.

The general coordination issue is a key one because it involves the optimum use of resources. The failure of our system to provide a healthy land monitoring system must be heeded. We need a merged program for weather, climate, ocean and land measurements, with close cooperation between government, private industry, and non-U.S. space agencies.

With the importance of global change now recognized, it is time for the United States to take the leadership in establishing a fully operational satellite-based system to monitor the global environment.

Thank you.

[The statement follows:]

STATEMENT OF

DR. D. JAMES BAKER
PRESIDENT, JOINT OCEANOGRAPHIC INSTITUTIONS INCORPORATED

Mr. Chairman and members of the Committee, I am pleased to be hear today to discuss briefly the earth science applications of NOAA satellite information. Instruments carried by NOAA satellites and the data system that supplies information to the user community: academic, industry, U.S. and foreign governments, are vital to documenting the state of our planet and the changes that are taking place in our global environment. There is hardly an area of earth science that has not been dramatically influenced by the availability of global information from satellites. Over the past 30 years, NOAA's 31 polar orbiting and 11 geostationary satellites have collected information on clouds and winds, atmospheric and earth surface temperatures, rainfall and snow cover, land cover, forests, and wetlands, ocean temperature and currents, and polar ice. Much of that information is now being used internationally for global change studies.

The request to testify mentioned specifically issues of global warming, deforestation, and acid rain. I will touch on each of these in my summary of the applications, and then summarize some funding and coordination issues.

To understand the earth well enough so that we can predict its future state, we must have global measurements. At the same time, the global measurements must have high enough resolution to show regional environmental changes. Satellite-borne instruments provide us with the tool to make accurate, high resolution measurements on a global basis. Today, we have a constellation of satellites circling the earth providing measurements of many of the key earth processes. These range from operational weather measurements to research missions that are testing new kinds of instruments and measurements for the atmosphere, ocean, and land surface. I will focus today on the operational NOAA satellites.

We know that our changing weather and climate are driven by energy from the sun. Measurements of the solar output have been made from rockets, satellites, and the Space Shuttle. Sounding rocket measurements began in 1976, as did measurements on the Nimbus series of satellites as part of the Earth Radiation Budget Experiment. NOAA geostationary satellites now routinely measure the solar output. Since climate change and solar output are linked, it will be necessary to continue such measurements indefinitely.

To understand the greenhouse effect and global warming, we need to know how the coupled climate system which includes the atmosphere, ocean, land, and biosphere works and how it is affected by increased concentration of greenhouse gases. Satellite-borne information is directly relevant by helping us observe changing concentrations of gases, the effects of clouds, the interactions of the oceans, and oceanic and terrestrial ecosystems.

The radiation from the sun interacts directly with the gases

of the atmosphere and the clouds. Clouds reflect a large part of the incoming solar radiation. Without clouds, the earth would absorb about twice as much radiation as it does with them. Clouds also trap radiation that is emitted from the earth. To understand climate change we need to know how these two large and competing effects, reflection and trapping, balance. Changes in cloud amount of just a few percent could have the same effect as doubling carbon dioxide in the atmosphere. Thus accurate measurements are required. In order to monitor global changes in clouds, the International Satellite Cloud Climatology Program of the World Climate Research Program is archiving satellite information on clouds collected from the constellation of operational geostationary and polar orbiting meteorological satellites. It is also possible to determine cloud height by using temperature and sounding data; maps of global cloud cover and altitude are currently regularly produced from operational satellites.

The Earth Radiation Budget Experiment (ERBE) was designed to measure both the radiation from the sun and the radiation reflected and emitted by the earth and its component parts. ERBE was launched in 1984 to provide long-term observations of the total amount of heat and light emitted from the sun, reflected solar radiation, and radiation emitted from the earth. These data are a key component of climate studies. The ERBE program combined observations from NASA's Earth Radiation Budget Satellite (ERBS) with measurements from the operational NOAA satellites. The ERBS failed earlier this year, and no U.S. replacement is currently scheduled. Recent results from the ERBE data show that the cooling effects of clouds exceeded the greenhouse warming effect. The net cooling effect was about four times as large as the expected warming effect of a doubling of carbon dioxide, suggesting that Earth would be considerably warmer without the cooling effects of clouds.

Other radiative effects come from volcanic eruptions that inject large volumes of dust and sulfur compounds into the stratosphere where they are transformed into sulphate aerosols. These particles have a net cooling effect on the earth's radiation balance, which can temporarily obscure other climatic effects such as warming produced by trace gases. Past variations in the frequency of such major eruptions can be associated with climate fluctuations. Recent examples of large eruptions include Mount St. Helens in the western U.S. in 1980 and Mount Chichon in Mexico in 1982, whose volcanic dust and acid droplets reduced sunlight reaching the earth by five percent. Satellite measurements have proved very valuable in monitoring the effects of these eruptions.

Human-induced increases in some of the trace gases, such as chlorofluorcarbons (CFCs), have been implicated in the sudden and large springtime decrease of ozone over the Antarctic, and in a lesser but significant decrease in ozone over the rest of the world during the entire year. Ozone, a three-atom molecule of oxygen, constitutes less than one part per million of the gases in the atmosphere, yet it absorbs most of the ultraviolet rays from the

sun, preventing them from reaching the earth. Such radiation can increase the incidence of skin cancer, cataracts, and immune deficiencies, and may also harm crops and aquatic ecosystems. If the ozone level in the stratosphere decreases, then the ultraviolet radiation at the surface will increase. Ozone measurements are made routinely by instruments on the NOAA satellites.

The most important and variable determinants of year-to-year changes in agricultural production are weather and climate anomalies. In order to predict weather and climate changes, it is necessary to know the distribution of temperature and water vapor in the atmosphere. The first weather satellites provided only pictures of clouds; in the almost thirty years since then there has been a continual record of improvement in weather sensing systems.

Today, operational weather satellites include both polar-orbiting satellites and geostationary satellites. Each polar-orbiting satellite views the whole globe twice each day, while each geostationary satellite repeatedly observes the full disk of earth in its view throughout the day. The satellite coverage includes conditions at the surface, in the intervening atmosphere, and at the spacecraft's altitude. The sensor observations are made with high precision in many spectral intervals and over a variety of energy levels. For a review of the operations of meteorological satellites, the recent book "Weather Satellites: Systems, Data, and Environmental Applications" by Rao et al. is recommended.

The U.S. polar-orbiting satellite system consists of two Advanced TIROS-N spacecraft flying in sun-synchronous orbit. The primary instruments are a radiometer and a sounder. The radiometer is the Advanced Very High Resolution Radiometer (AVHRR), a five channel scanning radiometer that produces images in the visible, near-infrared, and infrared spectral regions. The sounder is a TIROS Operational Vertical Sounder (TOVS), that produces profiles in both the lower and the upper atmosphere of temperature and water vapor in the infrared and microwave spectral regions. TOVS also provides vital ozone information.

In addition to the sounder and radiometer, the Advanced TIROS-N satellites also carry instruments to measure the solar irradiance, ozone profiles, and earth radiation. A space environment monitor provides data on solar emissions of protons, electrons, and alpha particles. Non-remote sensing systems include data collection systems and search and rescue systems.

A second U.S. polar-orbiting operational environmental satellite program, the Defense Meteorological Satellite Program (DMSP), is operated for the Department of Defense (DOD) by the U.S. Air Force. The mission of the DMSP program, which began in 1972, is to provide global visible and infrared cloud data and other specialized meteorological, oceanographic, and solar-geophysical data required to support worldwide operations of the Department of Defense. The primary difference between the DMSP program and the NOAA polar-orbiters is that the primary defense requirement is for

imagery for use in tactical operations, while the primary civil requirement is for vertical temperature and moisture profiles for incorporation into the world's twice daily synoptic forecast models. Data are supplied to both the Air Force and the Navy.

There are five geostationary satellites surrounding the earth today, two operated by the U.S., one by the European Space Agency, one by India, and one by Japan. The current U.S. system consists of two Geostationary Operational Environmental Operational Satellites (GOES). As of February 1989, only one of these is working, due to a failure in one of the encoding lamps. The replacement is not scheduled until 1991. In the meantime, the one satellite is moved during the year to provide the best coverage of storms and weather patterns. The GOES satellites provide operational weather data, cloud cover, temperature and water vapor profiles, real-time storm monitoring, severe storm warning, and sea surface temperature measurements. The complement of instruments includes visible and infrared imagers, infrared sounders, a space environmental monitor, a data collection system, and a search and rescue receiver.

The operational weather satellites provide regular ocean measurements, primarily of sea surface temperature. NOAA satellites provide sea surface temperature data weekly with an accuracy of close to 1 degree C. The main uncertainty in the data has come from the effects of water vapor in the atmosphere, but the multiple infrared channels on the new AVHRR have allowed significant reductions in the uncertainties to be made. These data have been useful in tracking ocean currents, and in relating biological changes to temperature. The data is not limited to oceans, but can also be used in the Great Lakes. Floating phytoplankton, algal blooms, and sedimentation are all measured regularly there.

The operational satellites have also been important in providing information about processes at the land surface. For example, volcanoes can be routinely detected. Forest fires and other high temperature locations, such as urban heat islands, are monitored. Snow and ice cover is routinely determined. Deforestation can be monitored closely using a combination of the NOAA satellites and the high-resolution Landsat and French SPOT systems. The effects of acid rain and drought can be determined. Today, land-cover patterns are studied to see if they remain constant in spite of weather effects on vegetation. Some areas now being studied include the tropical rainforest in Brazil, the tropical savanna in West Africa, the Prairie-Boreal Region in Canada, the Yellow River area of China, soil moisture in Australia, and tropical rainforest and wetlands in Thailand and Sumatra. The range of applications is broad, but it should be noted that the U.S. has not been willing to make a long-term commitment to the Landsat program. This high-resolution data is essential for such studies.

In summary, there is a broad-based need for continuing the

operational satellites. They have demonstrated their usefulness, and we must have the continuing information. The NOAA satellites are part of the global system that depends on their existence.

How can we ensure an adequate U.S. contribution to this global system? We need full funding of the operational satellite program, and close cooperation between U.S. agencies. For example, the close cooperation between NOAA and the DMSP series needs to be expanded to include ocean measurements. NOAA needs to make sure that it is fully interactive with the proposed Earth Probes and Earth Observing System of NASA. The data system planning for the EOS Data and Information system must involve all relevant agencies. Today, the areas of atmospheric science are better coordinated than those of oceans or land processes.

The general coordination issue is a key one, because it involves the optimum use of resources. The failure of our system to provide a healthy land monitoring system must be heeded. We need a merged program for weather, climate, ocean and land measurements with close cooperation between government, private industry, and non-U.S. space agencies. With the importance of global change now recognized, it is time for the U.S., to take the leadership in establishing a fully operational satellite-based system to monitor the global environment.

Senator KERRY. Thank you very much, Dr. Baker.
Mr. Rodenburg.

STATEMENT OF ERIC RODENBURG, RESEARCH DIRECTOR, WORLD RESOURCES REPORT, WORLD RESOURCES INSTITUTE

Mr. RODENBURG. I submitted some papers from the World Resources Report as testimony. I would like to summarize that.

Last week we published new estimates of tropical deforestation in the *World Resources 1990–1991.* These estimates showed an acceleration in deforestation during the 1980's, with the rate rising to as much as 50 million acres in 1987, fully 80 percent higher than levels seen by the FAO in their most recent tropical forest assessment, which however was performed in 1980.

While shockingly high, we believe these estimates are conservative and that as more assessments, objective assessments based on satellite imagery, become available, these numbers will rise.

The only reason we know anything about the extent of tropical deforestation, anything new, is because of some new satellite-based studies, principally through Landsat and NOAA polar orbiting AVHRR satellites.

Even though monitoring of the world's forests is far from perfect, without these satellites we would not know anything about the threat to global biodiversity because of the destruction of tropical forests, which contain over 50 percent of all species. We would not know anything about the loss of productive forest land as marginal soils are exposed to weathering and become permanently unproductive. We would not know anything about the extent to which deforestation adds to the gases that fuel the greenhouse effect.

Deforestation is responsible for one-third of the increase in carbon dioxide concentrations in the atmosphere. Primarily due to deforestation, Brazil ranks third among nations as a climate polluter. Other developing countries also already contribute to the ever-increasing load of greenhouse gases because of deforestation.

Estimates of deforestation are one of several unforeseen applications of satellite technology. They illustrate how people adapt tools to solve new or evolving problems. NOAA AVHRR satellites have been used to identify and enumerate the dry season fires in the Brazilian Amazon that Mr. Witte alluded to, and are the basis for an estimate of 20 million acres lost there in 1987.

As an aside, a promising new use of these AVHRR data is shown in recent work on the estimation of forest extent in Zaire and Madagascar based on observed differences in vegetation images that correspond to boundaries between evergreen forests, mixed forests, and savannah. If this new methodology is adopted by the FAO it could become a common empirical basis for new estimates of forest extent that would help to illuminate the 1990 FAO tropical forest assessment, which is scheduled for publication in 1992.

These AVHRR data, however, are difficult to use in studies of change, especially forest change, because the archiving and cataloguing of these data are very poor. Indeed there is a need to document what data do exist, what data have been maintained, and to maintain and make these data accessible to researchers.

This is clearly an easy step to take to ensure the usefulness of these data for years to come, and it is a small investment compared to the potential insights—that might come out of such an archive—into the processes of global change.

While AVHRR data has low spatial resolution, it has a high temporal resolution and it is easy and inexpensive to access. It has taken on a workhorse role in the assessment of forest health, forest extent, and general vegetative cover on the Earth.

Higher resolution, but higher cost, Landsat imagery provides greater detail and has been used extensively to monitor selected areas of forest where change has already been detected or predicted, for example in India and parts of Brazil.

A finer grain picture of forest condition extent is possible using Landsat imagery, and indeed, as Dr. Baker suggested, the two satellite tools together provide a possible cost effective tiered approach to remote sensing-based surveying of forests and open woodlands.

There is, however, no systematic approach now being implemented to perform forest assessment on a global scale. The satellite studies that added to our recent report were not the result of systematic monitoring efforts. They were all the result of special studies of burnings, special assessments comparing recent Landsat imagery to that of 10 years ago, or other one-time projects.

This is the precarious way we maintain our picture of the current extent of forests and our understanding of deforestation's threats to biodiversity, productivity, and climate. Without these satellites, we would be woefully ignorant of the current extent of deforestation and we would have no basis upon which to take any action.

Thank you.

Senator KERRY: Thank you very much, Mr Rodenburg.

Each of you has described in your own area the importance of the current satellite programs, and we appreciate your testimony. That is precisely why we wanted you here as we review and discuss our current and future for these programs.

But let me just ask you a few individual questions with respect to those areas. Mr. Rodenburg, how accurate are current assessments, based on what you just said? You say our techniques are really almost jury-rigged and often are not systematic, and that they could be improved by use of higher resolution data. Does that mean that we are to a large extent extrapolating our estimates today, and does it call into question these estimates?

Or is your point that the estimates we have today are adequate when satellite observations are used and will be that much better with the next generation of sensors?

Mr. RODENBURG. Certainly our understanding of the extent of deforestation is more accurate as a result of these satellite studies than it has been in the past. We would all like to have a more systematic monitoring effort with known measurements of potential error.

We believe, though, that what the new estimates show with certainty is the acceleration of deforestation throughout the 1980's.

Senator KERRY: What is being left out? We get the big picture of acceleration, but what are we missing?

Mr. RODENBURG. We are missing studies in specific areas. For instance, the great equatorial forests of Africa are poorly assessed, although efforts are currently under way to do that. One large problem with satellite systems is that you cannot see through clouds, and areas with large cloud cover, equatorial Africa being a prime example, are simply difficult to assess using Landsat imagery, for instance. Cloud cover is too extreme.

And because of that, there must be a greater emphasis on ground truthing, ground surveying, to relate what is seen on satellites with what in fact exists on the ground. In fact, that is one of those things that restricts the expansion of assessments using satellite technology. You must have ground truthing. Simply looking from the sky does not give you anything.

Senator KERRY: Would you suggest anything specific to us as we deal with this reauthorization in terms of either improving current use or making satellite information from NOAA more available for the purposes that you have been describing?

Mr. RODENBURG. Well, I was interested to hear what was being said this morning. I think that clearly one reason the low resolution AVHRR imagery has become such a workhorse is because it is also low cost. It is easily accessible to people.

Making Landset information available to researchers, opening the archives so that retrospective baseline studies can be performed and assessments of change can be made would be very valuable. But currently it would be a very expensive proposition for any researcher to propose doing that.

Senator KERRY: In your report you relied upon a significant amount of international data How important is the U.S. satellite system to the international community, would you say?

Mr. RODENBURG. Very important to the international community. Again, SPOT technology, while very high resolution, 20 meter multispectral and 10 meter panchromatic resolution, is very expensive, and it is not often used in third world nations or by third world foreign researchers in doing these kinds of studies, which are on a very large scale.

It is one thing to look at a small management unit in a U.S. national forest; it is quite another thing to try to assess the total U.S. forests using that kind of high-resolution, expensive imagery.

So AVHRR imagery, and Landsat imagery that has already been procured for other purposes and therefore is inexpensive to use by third world researchers, is used commonly. The studies that we relied on were all done by national scientists in the countries of concern.

Senator KERRY: Joe, let me ask you a question since you have given us a graphic and very meaningful description in the Hurricane Hugo scenario for why everybody in America has come to rely on, for any number of different reasons, that satellite picture. People have even become pretty good at getting a sense of a storm's flow and where it is going to go.

What is next? Can you see a next generation visual aid from satellite imagery and technology that will be transferred onto the screen and into a public use benefit at this point? I mean, beyond the propensity we have always to find some use for the new tech-

nology. Is there a specific benefit from improved technology that you at this point can see, or is it conjectural?

Mr. WITTE. Well, the first thing that comes to mind—I am not sure that this is quite what your question is about, but what I see down the line is, you are right, a lot of people are able to look at the spinning cloud mass and make an estimate. And one of the big emphases is on what we call now-casting, what is going to happen within the next twelve hours.

And we do have a weather channel. But I can see somewhere down the line where we have sort of a weather channel that has sort of a continuous loop of your area, of the satellite image, so that the person going out the door on Saturday morning to do his chores or going out on a trip, a short drive trip as opposed to across the country, or even across the country, you could turn on one channel and you could sort of see the loop.

It would be perhaps the loop channel, a local loop for your area and the other ones, so you have an idea: Oh gee, they are calling for showers this morning, and there is the back edge of the clouds sweeping over.

I am not quite sure that is what your question was about.

Senator KERRY: That is part of my question. But I am wondering if, as we think about the issues ranging from the very big and consequential ones like global warming to smaller issues, whether you would predict that we will see an immediate benefit from our move to this next generation of goes satellites.

Let me ask you the other side of that question.

Mr. WITTE. OK.

Senator KERRY: What happens to you and what is the down side if we have a no-GOES period?

Mr. WITTE. Oh, if we have a no-GOES period all TV weathermen across the country are stuck. We have no visual aid.

Senator KERRY: Because your mail would go up significantly.

Mr. WITTE. That is right. We would miss a lot of forecasts.

Seriously, from a no-GOES standpoint we do depend upon a GOES satellite image and a loop, again, to verify the forecast situation, to give us an idea of how fast things are truly running or moving, flowing through the air. And we are in a sense, as the scientists I am sure will say, sort of limited and handicapped by the fact that we just have one GOES satellite now, that we cannot show storms moving in the Pacific at this time of the year when the GOES bird is moving to the East Coast.

Fortunately, this is a quiet time of the year, of course, for the Pacific Coast. So if we have a no-GOES situation, it makes it more difficult to explain what is going on. It is not as visual for the folks to see what is going on.

Senator KERRY. Is it fair to say that the risk to people and property is in fact truly greater?

Mr. WITTE. Good point. I think we need to indeed narrow in on the life-threatening kind of weather. When it comes to hurricanes, when it comes to tornadoes, if we have a no-GOES situation we will truly be hard-pressed, though people these days, after Gilbert, after Hugo, do understand, I think, without all the visual. But it is certainly a help to look.

It will be difficult to convey the immensity of the storms. We do have radar and NOAA is putting in doppler radars which will enhance our capability for severe thunderstorms and tornadoes. And the radar range along the coast is not as great as we would like to have it, and that certainly is not going to give the folks enough warning.

So yes, without a GOES we would be hard-pressed to give the message. With the advanced GOES coming in, I do not know the details yet about how wonderful and terrific it is going to be, but my suspicion is it will certainly be of greater accuracy and clarity.

Senator KERRY. Gentlemen, we are going to be pressed by time because I have to leave to preside momentarily. I regret to cut this off, but I do have to be there.

Let me ask you, Dr. Baker. You served on the panel that put this report together and you heard the exchange that I had with Dr. Knauss regarding it. I would like to ask you as a member of the panel what your assessment would be of NOAA's progress towards achieving the rededication that is set forth here.

Dr. BAKER. I think NOAA's intentions are good, and I think they have the leadership in place, although I hope that we will see a new chief scientist appointed soon so that they will actually have their full leadership team in place.

I think that there has been relatively little progress, actually, in meeting those goals that the program talks about. And it is not an easy task. I do not envy the leadership.

Senator KERRY. What would be the most important things for us to focus on in the reauthorization process here?

Dr. BAKER. There are two things. One is that I think we spend a lot of money in the United States on satellite programs. We do not coordinate very well between agencies, between DOD, NASA and NOAA. The fact of that is seen with the problems that we have now, where we only have one GOES and we are not handling the Landsat situation very well.

We are not putting up the kinds of instruments that we could if we had the right coordination between DOD and NASA and NOAA. And the agencies, although they are talking about it, are not really fully coordinated with respect to the Earth Observing System.

So I think something about that coordination of satellite efforts on a national level is essential. I think the other thing that I would focus on is this problem of data, because it is ridiculous that the government is paying once for Landsat data and then suggesting that we might pay a second time to deliver it to particular communities.

Senator KERRY. What recommendation would you make for addressing that?

Dr. BAKER. Well, I think that we should be providing Landsat data. I think we should non-commercialize Landsat, that there should be an operation that combines land and ocean and weather remote sensing together.

I think private industry could play a very strong role there, and I think data should be made available on an equal access basis. But I think until you put those three elements together, the government and private industry and the user community, it is not going

to work. I think that is the only way you can really solve the satellite issue.

Senator KERRY. Well, I think that is a pretty sound grouping of priorities with respect to that issue, and I think Senator Gore and I are going to join our staffs together and try to follow up on that, because I think it would be very, very helpful, and very important to resolve our approach on that as soon as possible.

Is it technically feasible to use Landsat for coastal wetlands mapping?

Dr. BAKER. Yes. Landsat actually right now is providing very useful data on wetlands. In fact, that is one of the things that it is a very useful instrument for.

People are also buying SPOT data to do the same thing, and it was mentioned earlier that there will be some high resolution instruments proposed for the Earth Observing System that will do the same thing. But in the meantime, the high resolution Landsat and SPOT data are providing some valuable information for land use.

Senator KERRY. In your written testimony you used the word of a "merged" program for the weather, climate, ocean, land measurements. Is that what you were just talking about a moment ago in terms of coordination?

Dr. BAKER. Yes. There is no reason we cannot have operational ocean and land sensors flying as part of a polar orbiting and geostationary satellite system. It would mean a closer cooperation between DOD and NASA and NOAA, but there is no reason we cannot do it.

The Navy is now flying operational ocean instruments. With a little better coordination, we might have some of those instruments flying on NOAA satellites, for example. The same is true for the Landsat. But we have to have all of the data if we are going to do global change.

Senator KERRY. So the issue is one of coordination and management as much as anything?

Dr. BAKER. Yes, absolutely.

Senator KERRY. I appreciate all of you being as patient as you have been, and I apologize for my schedule constraints. I wanted to pursue some of the deforestation findings of the report, which I have read and find intriguing. We have now bounced from Tennessee, I guess, to the State of Washington, in the extent of deforestation, is that right? I hope we do not reach Texas, but the trend is not very hopeful.

Perhaps I could submit a couple questions in writing. I did want to particularly ask you about the policy implications of your report, even though that is aside from the satellite issue, and I might do that in another form.

Thank you all very, very much. We stand adjourned.

[Whereupon, at 11:59 a.m., the meeting was adjourned.]

[The following information was subsequently received for the record:]

STATEMENT OF

THE AMERICAN SOCIETY FOR PHOTOGRAMMETRY AND REMOTE SENSING

AND

THE AMERICAN CONGRESS ON SURVEYING AND MAPPING

We, the American Society for Photogrammetry and Remote Sensing (ASPRS) and the American Congress on Surveying and Mapping (ACSM), appreciate the opportunity to present our views and concerns about the future of the Landsat program.

ASPRS and ACSM are national professional and technical societies with a combined membership of 18,000 individuals. Our members are involved in photogrammetry, remote sensing, land and geographic information science, surveying, and mapping.

The images derived from the Landsat satellites are important to our membership. The Landsat satellites provide crucial data needed to address global information resources. Those involved in solving environmental problems facing humankind's existence today such as global warming, deforestation, acid rain, and soils depletion need the information that only Landsat can provide to monitor and assess changes in these conditions. Likewise, Landsat is crucial to environmental intelligence and national security intelligence gathering.

Our members in the remote sensing community have used Landsat data for decades to compile topographic maps, geologic maps, soils maps, tax maps, wetland maps, orthophotos, forest cover maps, and an array of other land use/land cover maps. A major concern raised by our members since commercialization of Landsat is the change in the data pricing structure which has affected the availability of Landsat data at reasonable costs, particularly for those in the scientific and academic communities.

Also, remote sensing data acquired from Landsat is important to the surveying and mapping community because it is crucial for creating the base maps used for geographic/land information systems. Geographic/land information systems are proliferating at all levels of government and the private sector. These systems are becoming critical resources that provide assistance in such areas as land planning, management and development, environmental and forestation management, mineral resource management, tax assessment, etc.

Because of our interest and concern about the Landsat program, we wish to offer the following thoughts for review and consideration by the committee as it addresses NOAA's environmental satellite programs:

Landsat Commercialization

ASPRS and ACSM believe that Landsat commercialization has not worked as originally envisioned. Landsat provides fundamental data about the Earth and as such, we believe this data should be managed as a public resource. The data belongs in the public domain so it can be widely utilized.

Landsat data is not currently available at reasonable costs from the commercial operator. Moreover, sharing of this data is prohibited under the commercialization contract. This limits scientific and academic research, particularly in such critical areas as environmental assessments and climate and global change research.

At present, the Landsat satellites only monitor the Earth when the commercial operator has a customer who requests the data. This policy is detrimental to research programs that need baseline data from Landsat to assess changes over extended periods of time.

ASPRS and ACSM request that Congress propose changes to the commercialization act to allow a more sensible pricing structure and to make more Landsat data available to the scientific and academic communities, and allow sharing of Landsat data for research purposes.

Earth Observing System and Landsat

Some confusion exists about the Earth Observing System (EOS) replacing the Landsat program. Landsat is the only United States civil satellite program producing detailed, comprehensive data of the Earth's surface at a moderate resolution for the next decade. EOS is not a substitute for Landsat. EOS and Landsat are distinct and complementary programs. EOS is NASA's research program to provide the scientific basis for improved understanding of global changes. In fact, EOS requires Landsat and its historical data to properly operate.

We urge Congress to review the missions of these programs and not be misled to believe that EOS could replace Landsat.

Funding Concerns

ASPRS and ACSM believe the Administration has shown a lack of commitment to the Landsat program by not requesting funding for Landsats 4 & 5 in its original FY '91 budget. This lack of funding commitment causes a negative impact on the use of Landsat data by user agencies and the scientific community.

We are also concerned that no funds have been earmarked to continue Landsat beyond the current commitment to Landsat 6, even though Landsat is the only United States civil program that can perform detailed Earth-sensing for the next decade.

ASPRS and ACSM urge the Administration and the National Space Council to move expeditiously to determine policy concerning the follow-on satellite for Landsat 6. This is crucial so that necessary funding will be included as federal agencies are now determining their budget requirements for the FY '92 budget cycle.

Landsat must be properly managed and directed with the appropriate funding support to accomplish its mission. The National Oceanic and Atmospheric Administration (NOAA) has admitted that it has not done the best job in managing Landsat because of funding cutbacks. We urge Congress to assist the National Space Council in finding an appropriate civil agency to manage and direct the Landsat program and assure that the chosen agency will receive the necessary funding support.

Follow-on the Landsat 6

ASPRS and ACSM believe that the National Space Council and Congress should review the formal proposal made by the Department of Interior to NOAA for the follow-on to Landsat 6. The Department of Interior has recommended a configuration for the follow-on satellite that is reasonable and cost-effective, and has considerable international support. The concept has been endorsed by ASPRS and ACSM.

Finally, ASPRS and ACSM have attached a letter sent to Vice President Quayle by the ASPRS and ACSM presidents this past March. This letter summarizes many of the comments previously made about the Landsat program. In closing, we would like to reiterate our belief that the United States needs a clear, long-term policy for a strong civilian remote-sensing program. ASPRS and ACSM would like to offer its technical advice and assistance in working with Congress, the Administration, and the National Space Council to address policy issues surrounding the future of the Landsat program.

STATEMENT BY THE
EARTH OBSERVATION SATELLITE COMPANY
FOR THE
NATIONAL OCEAN POLICY STUDY SUBCOMMITTEE
OF THE
SENATE COMMERCE, SCIENCE AND TRANSPORTATION COMMITTEE

12 June 1990

Background

In 1984 the U.S. Congress codified and the President approved the Land Remote-Sensing Act of 1984 (P.L. 98-365). This visionary legislation permitted the Secretary of Commerce to begin the process of transferring the U.S. Landsat program from government to private sector control. This process was formalized by a contract award to the Earth Observation Satellite Company (EOSAT) in September 1985.

EOSAT was formed as a joint venture partnership by General Electric's Astro Space Division (formerly RCA) and Hughes Aircraft Company to commercialize Landsat. EOSAT's International Marketing, Management, and Administration Headquarters are located in Lanham, Maryland.

Under authority granted by the contract, EOSAT would develop, construct, launch and operate two spacecraft, Landsats 6 and 7. In addition, the government would continue to fund the operations of Landsat 4 and 5 through their practical demise. EOSAT, in turn, was obligated to fund the operations of Landsat 6 and 7. Over the ten year contract period the government would oversee Landsat while EOSAT would aggressively work at developing new markets for remotely sensed data.

This was a good plan. However, no one could have foreseen or predicted the turmoil which beset the process from its inception. Funding difficulties experienced by the government (Department of Commerce) and the Challenger tragedy combined to nearly immobilize the Landsat commercialization initiative. If it were not for the leadership of the Senate and House committees which oversee the process, the fledgling commercialization program and the U.S. industry developed around it for the past 18 years would have failed.

Congress, however, saw and understood the importance of the Landsat program, not only as it sup-ports domestic requirements, but also in its maintenance of U.S. international obligations to the global network of Landsat ground receiving stations. Because of this understanding, Congress has maintained its strong support, and participated in restructuring the original Department of Commerce contract in April 1988 which resulted in a reduction to a single spacecraft and downsized ground processing capability. As part of this contract, EOSAT is investing $10.8 million of its own capital into the development of the Landsat 6 program. Most recently, in March 1989, the Bush Administration through the leadership of Vice President Quayle and the National Space Council has reaffirmed that Landsat should be maintained. We are encouraged by the diligent efforts which the National Space Council has undertaken to address the issue of commercialization of space and the continuation of an advanced U.S. remote sensing program.

Program Status

When EOSAT assumed control of the Landsat program in 1985, the U. S. taxpayer was investing $36 million a year to operate one healthy spacecraft, Landsat 5, and the partially disabled Landsat 4. The cost of the principal data product, a Thematic Mapper Computer Compatible Tape (CCT) had risen to $4,400 per scene and system revenue totaled approximately $12 million with most of these monies generated from sales to other government agencies.

Today, four-and-a-half years later, operating costs have been reduced to $19 million a year, $10 million of which is used by NOAA for other government agency support. These fees cover the cost for a robust Landsat 5 and a reactivated Landsat 4. EOSAT with the cooperation and concurrence of NOAA and NASA reestablished an operations scenario for Landsat 4 which permits us to utilize this resource to produce useful data for customers around the world. This year, Landsat 5 has already begun its sixth year of operation, while Landsat 4 will enter its ninth year this summer. These spacecraft have far exceeded their three year engineering design life. EOSAT has initiated a life extension program for both Landsats in order to ensure that there will be little or no data gap prior to the launch of Landsat 6, currently scheduled for late 1991. Today, the cost of a Thematic Mapper CCT is $3,960, still 10% below the level set by the government in 1985, and only slightly more than the cost of product production. Since 1985, customer base for Landsat data contines to grow at approximately 20% per year. This growth has occurred despite the fact that no new data has been introduced in the market place, thus meeting the expectation of Congress, expressed in Title II of Landsat statute, for 'Marketing of Unenhanced Data'. Total Landsat world-wide revenues in 1989 slightly exceeded $25 million. Although U.S. government agencies continue to use Landsat data at 1985 levels, their proportion of revenue generation has declined as we see significant growth in other market sectors. We are encouraged by the new use of Landsat data in such commercial market segments as franchise and warehousing businesses, the agricultural and forest industries, and a recent trend by conservation and envrionmental groups.

The Enhanced Thematic Mapper (ETM), the next generation instrument payload for Landsat 6, is entering final system test and calibration at Hughes Santa Barbara Research Center. We anticipate that the ETM will be ready to ship to General Electric for integration with the spacecraft by late fall of this year. By March of 1991, all the major system components will have been integrated with the spacecraft and environmental tests completed. The Landsat 6 structure and payload components will be shipped to the Western Test Range by late summer of 1991. The spacecraft and the Titan II will be mated and final testing completed to be ready for a launch in December 1991.

Based on our continuing evaluation of the health and well being of Landsats 4 and 5, we estimate that Landsat 4 (which NOAA estimated would cease operating in October 1983) will continue to produce useful into 1991 while Landsat 5 will maintain service well beyond 1991 and could still be operating at the launch of Landsat 6. Both spacecraft are currently operating on back-up systems, and as stated earlier, both are being operated on a reduced schedule to extend their utility. We continue to support the full requirement of the 16 International Ground Receiving stations on the network, and customer orders.

Market Conditions

As indicated earlier, EOSAT's primary responsibility is in the area of market development. In 1985, EOSAT reduced the price of digital data (this item represents 90% of the data sold, and nearly 100% of the data requested by the science community) and increased photo prices to focus customer attention on the value of digital data. We moved to double the system production, and we introduced different ways to package the digital data.

Presently, we offer a range of digital products that accommodate the user's preference. We are continually seeking new media for data delivery. We are especially interested in implementing media that could be directly utilized by the growing number of PC based image processing systems. This past March we implemented a major change in software format in order to improve our processing efficiency and to make the data more accessible by the digital data user. This change has been widely accepted and heralded by the digital user community.

In 1989, we introduced a new higher quality photo product which delivers to the customer a second generation photo product from a digital tape. Prices have been raised to reflect the increased technology and the amount of computer resources necessary to generate a quality

photo product. This month we have expanded the photo product line to include a new color print at 1:50,000 scale which is the most used mapping scale for resource development in third world countries. Although Landsat photo products now sell at a premium price, we have seen no downturn in orders from the market place. We believe that this is occurring because the customer sees the value of the improved photo quality.

Since 1985 we have seen a steady growth in the Landsat remote sensing market. We attribute this growth to the introduction of new product packaging schemes and to the introduction of a new domestic sales force and the increased number of international sales representatives. Despite the funding difficulties during the beginning phases of the program, we are happy to report that the market for remote sensing data continues to grow at 20 percent a year.

Many factors affect market growth, and certainly the confidence of the marketplace must not be discounted. In 1985, Landsat was the only commercial source of remote sensing data world-wide. Today, the French and Soviets commercially market remote sensing products from their space systems. Japan and India operate systems capable of delivering high quality remote sensing products to the market place. By 1995 we expect to see a doubling of systems capable of competing for consumer dollars. Customers who resisted investing in remote sensing analysis sytems in the 1970s and 1980s because Landsat was the only source of data are now entering the market because they can be assured that some form of remote sensing data will be available, even if they are forced to buy from a foreign system.

EOSAT understands the necessity of supporting applied research and development programs to maintain the U.S. preeminence in remote sensing technology and retain its position of commercial leadership . There was a general reduction in government funding to the science community for applied research during the the 1980s. However, in 1988 NASA was able to reestablish a small applications research effort and revitalize their efforts in development of commercial programs. During 1989 NASA and EOSAT formalized an agreement whereby EOSAT has provided $250,000 of Landsat data to support NASA's Earth Observation Commercialization/Applications Program (EOCAP). In addition, EOSAT supports a significant number of small research studies, primarily with value-added firms, who want to focus on developing new applications for Landsat TM data. We are encouraged by the positive response we have to these programs, and by their potential to expand the applications of Landsat TM data.

Today, the user community sees other governments willing to invest in space hardware and ground systems. This means that two conditions are being met, 1) space remote sensing makes good business (commercial) sense, and 2) because of the number of systems, consumers do not have to rely totally on one system. In effect, there will be a continuous supply of commercially competitive data from space.

Outlook for the Future

EOSAT market studies show that customers will continue to demand data in the visible, near infrared and short wave infrared regions of the spectrum, because these bands deliver the greatest amount of information. In addition, we have also found that frequent repeat coverage is critical to some users, as is the requirement stereo data from which elevation and topographic information may be derived. Lastly, there is a market for very high resolution coverage by the news media, the science community, for arms control verification, and urban planning.

We feel that these market demands can be met during the Landsat 7 era. The table below is one possible scenario which EOSAT proposed in January 1989, for the payload of Landsat 7.

LANDSAT 7 CAPABILITIES

INSTRUMENT	SPATIAL RESOLUTION	COVERAGE FREQUENCY	APPLICATION
Wide-Field-of-View Sensor	500 meters	Every other day *(compliments NOAA data sets)*	Global agriculture production monitoring Global forest survey Weekly regional vegetation indicies
Enhanced Thematic Mapper *(continuity instrument, will have provided nearly three decades of data by the completion of the Landsat 7 mission)*	15 -120 meters	Once every 16 days	Land resource management Land cover mapping and monitoring Geologic exploration Bathymetirc mapping
High Resolution Imager	5 meters	Daily with use of pointable optics	News events Urban mapping
Stereo	10 meters	Once every 16 days with pointable optics	Topographic maps

Furthermore, we believe that such a mission could be launched by mid-1996 if new-start funds were authorized during the next budget cycle.

International investment in the program is possible and could be utilized to offset expenditures from the U.S. Treasury, if the U.S. decides to move away from a 'National' Program. This investment may be in the form of an instrument which would fly on a U.S. spacecraft, or a U.S. spacecraft on a foreign launch. Although such opportunities may be limited now, we believe that the possibilities for international involvement will increase by the mid-to latter part of the decade.

Recommendations

We encourage the committee to review and approve the continued funding of the operations of Landsat 4 and 5 at the level consistent with the past fiscal years. This will provide confidence to the international commercial community of users as well as supporting U.S. international commitments to the ground station owners.

We also encourage the committee to work closely with the Vice President and the National Space Council in defining requirements for the U.S. Advanced Civil Land Remote-Sensing System (Landsat 7), and release funds on a level and in a timely fashion tosupport the U.S. commercialization objectives of Public Law 98-365.

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